

CAPE CANAVERAL AIR STATION, LAUNCH COMPLEX 17  
East end of Lighthouse Road,  
0.25 miles east of IRBM Road  
Cape Canaveral  
Brevard County  
Florida

HAER No. FL-8-5

HAER  
FLA  
5-CACAN,  
1-

**PHOTOGRAPHS**

**WRITTEN HISTORICAL AND DESCRIPTIVE DATA**

Historic American Engineering Record  
National Park Service  
Southeast Region  
Department of the Interior  
Atlanta, GA 30303

# HISTORIC AMERICAN ENGINEERING RECORD

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**Location:** Cape Canaveral Air Station,  
Launch Complex 17  
East end of Lighthouse Road,  
0.25 miles east of IRBM Road  
Cape Canaveral  
Brevard County  
Florida

USGS Cape Canaveral Quadrangle,  
Universal Transverse Mercator Coordinates: Zone 17  
Northing 3146560 Easting 542520

**Date of Construction:** 1956-57

**Engineer:** U.S. Army Corps of Engineers

**Present Owner:** United States Air Force

**Present Use:** Delta II Space Launches

**Significance:** Launch Complex 17 has played a key role in the American space program by supporting over 260 launches since 1957. Constructed in 1956 and 1957, the complex originally supported the Air Force's Thor IRBM research and development program. In the late 1950s, the complex began supporting space launches as well. The early space launches at the complex involved Thor boosters in combinations with various upper stages. The Delta space launch vehicle made its debut at the complex in May 1960. Since April of 1965, the complex has exclusively supported Delta space launches. Included among the wide variety of payloads launched at Complex 17 are important research, weather, communication, application, and military satellites, many of which were the first ever of their type. Through continuous upgrades, Launch Complex 17 continues to be a vital space launch facility.

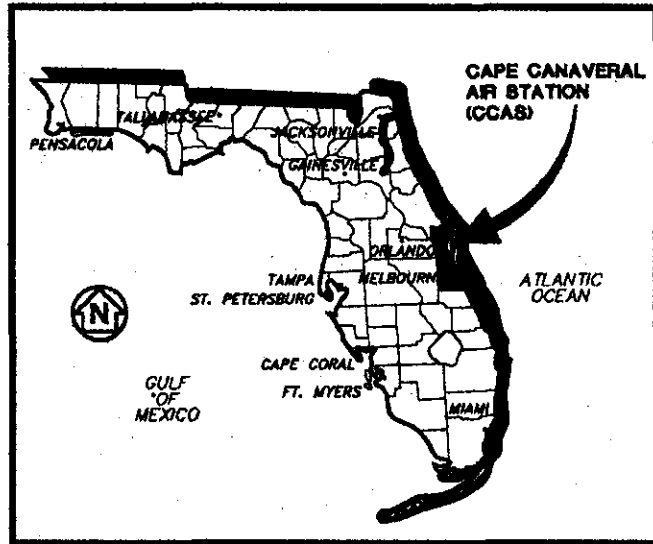
**Report Prepared by:** Sheila Ellsworth and Patrick Nowlan  
U.S. Army Construction Engineering Research Laboratories  
2902 Newmark Drive  
Champaign, Illinois 61826-89005

**Date:** December 1997

## HISTORICAL OVERVIEW OF CAPE CANAVERAL AIR STATION

### Cape Canaveral Air Station

Cape Canaveral Air Station (CCAS) is located in Brevard County on the east coast of Florida, approximately 155 miles south of Jacksonville and 210 miles north of Miami. It occupies 15,804 acres and is bounded by the Atlantic Ocean to the east and the Banana River to the west. A barge and ship channel called Port Canaveral is located to the south while the John F. Kennedy Space Center is located to the north.<sup>1</sup> Cape Canaveral Air Station is part of the Air Force Eastern Range which includes administrative headquarters at nearby Patrick Air Force Base, launch sites at Cape Canaveral, and downrange tracking facilities that extend 10,000 miles down the Atlantic into the Indian Ocean.



Location Map of Cape Canaveral Air Station

### Cape Canaveral and the Cold War

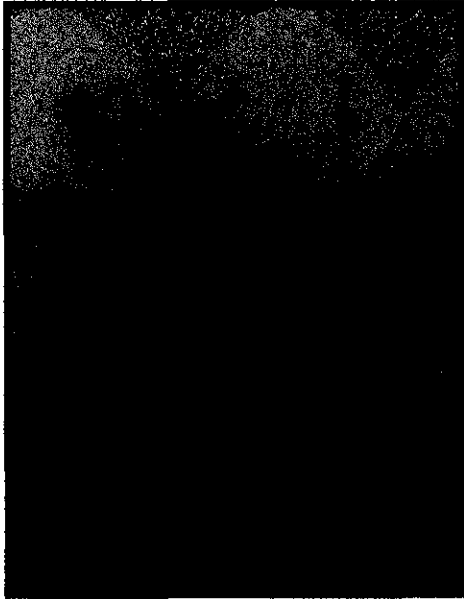
As the launching site for a majority of the United States' missile and space programs, both military and civilian, CCAS played a critical role during the Cold War. This era in history, spanning roughly from 1946 to 1989<sup>2</sup>, pitted the ideologies, economies, technologies, and military power of the United States and the Soviet Union against each other. This struggle originated in Europe but eventually spread around the globe. The defining feature of the Cold War was the massive arms race that developed between the Soviet Union and the United States. This arms race relied heavily on constantly advancing technology. The Soviet Union and the United States both developed massive missile and space programs after World War II. Although military and political goals fueled the early missile and space efforts of the United States, one important offshoot of these efforts was the emergence of a separate civilian space program. The civilian space program, which included both manned and unmanned missions, grew alongside and benefited from the military missile and space programs. The military programs, in turn, also benefited from the successes of the civilian space program.

<sup>1</sup> David Barton and Richard S. Levy, An Architectural and Engineering Survey and Evaluation of Facilities at Cape Canaveral Air Force Station, Brevard County, Florida (Resource Analyst, Inc., 16 March 1984), 1.

<sup>2</sup> These dates correspond to Winston Churchill's "Iron Curtain" speech delivered at Westminster College in Missouri and the destruction of the Berlin Wall, an event generally accepted as signifying the end of the Cold War.

### Origins of the U.S. Missile Program

America's early efforts in rocketry revolved around the work of Robert H. Goddard. Goddard conducted experiments with rockets in the 1920s and 1930s, carrying out the first recorded launching of a liquid-propelled rocket in 1926.<sup>3</sup> Some of Goddard's more impressive achievements include adapting the gyroscope to guide rockets, installing movable deflector vanes in a rocket exhaust nozzle scope to guide rockets, patenting a design for a multistage rocket, developing fuel pumps for liquid fuel motors, experimenting with self-cooling and variable thrust motors, and developing automatic parachute deployment for recovering instrumented rockets.<sup>4</sup>



Dr. Wernher Von Braun at  
Fort Bliss

Around the time Goddard was conducting his experiments, the German's were also engaging in rocket research. In 1937 and 1938, they established huge research and test facilities at Peenemünde on the Baltic where they developed the V-1 "buzz bomb" and the more advanced V-2 ballistic rocket. Although the U.S. military experimented with some crudely developed guided missiles during World War II, there was not much interest in rocketry among United States military leaders until the Germans began firing their V-1 and V-2 rockets at Allied cities in the summer of 1944. Allied anti-aircraft batteries quickly learned to shoot down the slow-flying V-1. There was no defense, however, against the 3,500 mile-per-hour V-2. The German V weapons made it clear that missiles would revolutionize the future of warfare. Recognizing this, the different branches of the U.S. armed services scrambled to create their own missile programs, each hoping to gain future operational and deployment responsibility.

Immediately after World War II, the Army brought several hundred German engineers and scientists, including Dr. Wernher von Braun, to the United States during Operation "Paperclip". The Army organized a team of these scientists at Fort Bliss, Texas to conduct studies concerning the development of long-range surface-to-surface guided missiles. In an effort to refine the German V-2, these scientists began helping the Army test launch captured V-2 rockets at the adjacent White Sands Proving Grounds in May 1946. In 1951, the Army moved the team to the Redstone Arsenal in Huntsville, Alabama, where they began to develop the Redstone missile.

The Navy and Air Force also began their own missile programs in the 1940s. For a brief time, however, it appeared that a single national guided missile program might be established to eliminate duplication of effort among the services. The Army and Navy both favored such a

<sup>3</sup> Young, Warren R., ed., To The Moon (New York, NY: Time-Life Records, 1969), 21.

<sup>4</sup> Ibid., 18.

development. But the Air Force (at that time still known as the Army Air Forces or AAF)<sup>5</sup> strongly opposed such a plan. AAF officials feared that a single program would jeopardize their chance of gaining sole responsibility for development and deployment of long range guided missiles.<sup>6</sup> Consequently, fierce inter-service rivalries developed as each service sought to define its role and mission in the development and control of guided missiles.

In 1949, Secretary of Defense Louis A. Johnson initiated a review of the nation's missile programs in an attempt to clarify the roles of each service branch and to reduce the waste resulting from the duplication of effort. The Air Force emerged from this review with "formal and exclusive" responsibility for developing long range strategic missiles and short-range tactical missiles. Even after the review, however, both the Army and Navy continued to conduct missile "studies" that eventually progressed to the development stage.<sup>7</sup>

Aside from the inter-service bickering, a major obstacle to long-range missile development for the United States in the 1940s was lack of a range large enough to test new missiles. The nation's largest missile range in 1946 was the White Sands Proving Grounds in New Mexico and it was only 150 miles long.<sup>8</sup> In order for the United States to develop long-range missiles, a new missile proving ground would have to be established.

#### **Committee on Long Range Proving Grounds**

In October of 1946, the Joint Research and Development Board of the War Department (later the Department of Defense) created the Committee on Long Range Proving Grounds. The War Department charged the committee with the task of selecting a site that would be suitable for a long range proving ground. The committee considered sites in California, Georgia, Texas, and Florida.<sup>9</sup>

The committee's first choice was the El Centro Marine Corps base in the Gulf of California area. The U.S. government immediately initiated negotiations with the Mexican government to secure sovereignty rights for tracking stations. When these negotiations failed, the committee then recommended the Cape Canaveral area in Florida. Cape Canaveral had several factors working in its favor, not the least of which was an over-water range that would allow long-range missile flights over an area relatively free from major shipping lanes and inhabited land masses. In addition, the numerous islands extending out into the Atlantic Ocean offered suitable locations for permanent stations to track missile flights and record performance information. The relative isolation of the Cape area was ideal for safety and security reasons and the weather conditions of the area would allow for year round operation.<sup>10</sup> Also, the Banana River Naval Air Station,

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<sup>5</sup> The National Security Act of 1947 divided the military services into the three separate departments of the Army, the Navy, and the Air Force.

<sup>6</sup> Jacob Neufeld, The Development of Ballistic Missiles in the United States Air Force, 1945-1960 (Washington, D.C.: Office of Air Force History, United States Air Force, 1990), 50-52.

<sup>7</sup> Ibid., 55-56.

<sup>8</sup> "Cape History: Establishment of the Eastern Test Range," Spaceport News, 14 October 1977.

<sup>9</sup> Barton and Levy, 3.

<sup>10</sup> From Sand to Moon dust: A Narrative of Cape Kennedy, Then and Now (U.S. Air Force and Pan American World Airways, Inc., 1974), 9.

located only about twenty miles from the Cape, would make an ideal support base. Aside from these advantages, locating the missile proving ground at Cape Canaveral also had economic advantages. The U.S. government already owned portions of the Cape and the undeveloped land on the Cape was considerably less expensive than land at other locations.<sup>11</sup>

### Initial Developments

The Department of Defense accepted the committee's recommendations and officially chose the Cape Canaveral area as the site for the envisioned missile test center. In May of 1949, President Truman signed Public Law 60 authorizing the establishment of the joint long range proving ground to be used by the Army, Navy and Air Force for the development and testing of missiles and other weapons.<sup>12</sup> The Department of Defense assigned responsibility for developing the range to the newly created Department of the Air Force. Brig. General William L. Richardson was named to direct the project.<sup>13</sup> During the next few years, the U.S. Government acquired land in the Cape area and began negotiations with the British government to acquire islands in the Bahamas and West Indies for use as tracking sites. The negotiations concluded with the signing of the Bahamas Agreement in July of 1950, permitting construction of downrange stations on such islands as Grand Bahama, Grand Turk, Antigua and Ascension.<sup>14</sup> Future downrange stations were added as far away as Pretoria in South Africa.

On June 10, 1949, the Banana River Naval Air Station was reactivated and an advance headquarters was set up there on October 1, 1949.<sup>15</sup> Brigadier General Richardson assumed command the following April. The name of the Banana River Naval Air Station was changed in August of 1950 to Patrick Air Force Base in honor of Major General Mason M. Patrick, the Army Air Corps' first Chief. During that same year, construction began on the first missile launching pad (Pad 3) and the first support facilities at Cape Canaveral. In June, Cape Canaveral was officially declared operational and became Operating Sub-Division #1 or Station 1 of the Joint Long Range Proving Ground.<sup>16</sup>

### Name Changes

Over the years the installation at the Cape, and the entire range, underwent numerous name changes. Initially known as the Joint Long Range Proving Ground, the range became known as the Long Range Proving Ground in 1950. By 1952, it was known unofficially as the Florida Missile Test Range and on May 1, 1958, it was officially designated the Atlantic Missile Range. The name was changed once again in May of 1964 to the Air Force Eastern Test Range (AFETR). The latest redesignation occurred in the fall of 1990 when the range became simply the Eastern Range. Operating Station 1 or Sub-division #1 was commonly known as Cape

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<sup>11</sup> Barton and Levy, 3.

<sup>12</sup> "Cape History: Establishment of the Eastern Test Range."

<sup>13</sup> Master Plan of the Cape Canaveral Missile Test Annex (Pan American World Airways, Inc., 1971), 1.

<sup>14</sup> "Cape History: Establishment of the Eastern Test Range."

<sup>15</sup> The Navy had transferred the installation to the Air Force several years earlier.

<sup>16</sup> Barton and Levy, 4.

Canaveral from 1950 to 1963.<sup>17</sup> In November of 1963 the Cape area was officially named Cape Kennedy in honor of President Kennedy, but early in 1974 the name was changed back to Cape Canaveral.<sup>18</sup> In April 1994, the name was changed yet again to Cape Canaveral Air Station.

### **Land Acquisition in the Cape Area**

The U.S. government contracted with Sverdup and Parcel to conduct a land survey of the Cape Canaveral area in January of 1948. The government began acquiring land on the Cape in 1950. Of the original 12,000 acres acquired, 2,328 acres were purchased by the end of 1950. The U.S. government acquired the south half of the launching area as a result of condemnation petitions from April to June of 1950 and acquired the north half of the launching area in June of 1950. In 1951, the value of government-acquired land and facilities at the Cape totaled about \$7,500,000.00.<sup>19</sup> In 1956 and 1957, the government acquired an additional 682 acres in the south Cape area and from 1956 to 1959, 1,924 acres were acquired in the north Cape area. The total acreage at the Cape by 1959 was approximately 14,600 acres.<sup>20</sup> Later acquisitions brought the total up to 15,804 acres.<sup>21</sup>

## **Construction History of Cape Canaveral**

### **Early Construction at Cape Canaveral**

Extensive construction was necessary to prepare Cape Canaveral for its role as a missile research and development test center. The first facilities built at Cape Canaveral were technologically primitive by today's standards. Many of the early structural designs became obsolete as missile technology advanced. Although facilities within launch complexes were often adapted and re-used for other functions, launch complexes designed for one type of missile or missile series were rarely used for subsequent missile programs because complexes that were useful for one missile or missile series were not configured to handle the later, often larger and more sophisticated missiles. It was generally more cost effective to build a new launch complex than to adapt an existing launch complex. Some obsolete complexes were salvaged for re-usable metal, sold to scrap metal dealers, demolished, or in a few cases used in the testing of anti-tank weapons.<sup>22</sup>

The Department of Defense designated the Corps of Engineers as the prime construction agency at Cape Canaveral and nearby Patrick Air Force Base. The Jacksonville District Corps of Engineers established a small area office at Patrick Air Force Base in May of 1950 and awarded a contract for the construction of the first launch pad at the Cape. The launch pad (Pad 3) was

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<sup>17</sup> Ibid., 9. Between October 5, 1951 and December 15, 1964, the Cape was designated as Cape Canaveral Auxiliary Air Force Base. Between December 15, 1955 and January 22, 1964, the Cape carried the designation Cape Canaveral Missile Test Annex.

<sup>18</sup> Barton and Levy, 9.

<sup>19</sup> Master Plan of the Cape Canaveral Missile Test Annex, 2.

<sup>20</sup> Barton and Levy, 4.

<sup>21</sup> Ibid., 1.

<sup>22</sup> Ibid., 55.

completed by June of 1950.<sup>23</sup> During the following month, the Army used the pad to launch the first missile from Cape Canaveral.

The Canaveral area office of the Corps under the Jacksonville District supervised and inspected \$1.7 million in construction work and \$.7 million in road contracts in the six months after the Bumper launch.<sup>24</sup> During the next three years, contractors constructed facilities for testing of cruise type missile weapons such as the Matador, the Snark and the Bomarc. The Air Force test-launched these missiles from Complexes 1 through 4. These complexes were located in an area northeast of the lighthouse at the point of the Cape. Other structures built in the area around this time included a communications building, a water plant, a fire station and several camera tower roads. Tracking stations, an administrative area, and a bivouac area were built just northwest of this point. A skid strip was constructed in the center of the Cape and more camera tower roads, a guidance station, sky screen stations, a fuel storage area, a tracking station, a transmitter building, headquarters, and a guard house were built south of the launching pads.<sup>25</sup>

The construction of Port Canaveral, a deep water port located at the south end of the Cape, began in July 1950 and continued through 1952. The Corps of Engineers carried out the dredging of the port. Ships delivered missile components at Port Canaveral and the Navy docked and serviced its tracking ships and missile launching submarines there as well.<sup>26</sup>



Port Canaveral

In June of 1953, the Air Force contracted with Pan American World Services for the operation and maintenance of facilities and equipment at Patrick Air Force Base and Cape Canaveral.<sup>27</sup> Pan American chose the RCA Service Company as its primary sub-contractor for communications, photography, and electronic and optical tracking services. The management and direction of range operations remained the responsibility of the Air Force Missile Test Center. Air Force, Army, and Navy personnel and missile contractor personnel conducted missile checkouts and launchings.<sup>28</sup>

Originally, contractors delivered missile components to Patrick Air Force Base. The contractors assembled the missiles at the base and then transported them by truck to the launching pads at the Cape. Because the bumpy ride to the Cape caused problems for the delicate missile parts, the Air

<sup>23</sup> "Cape History: Establishment of the Eastern Test Range."

<sup>24</sup> Barton and Levy, 6.

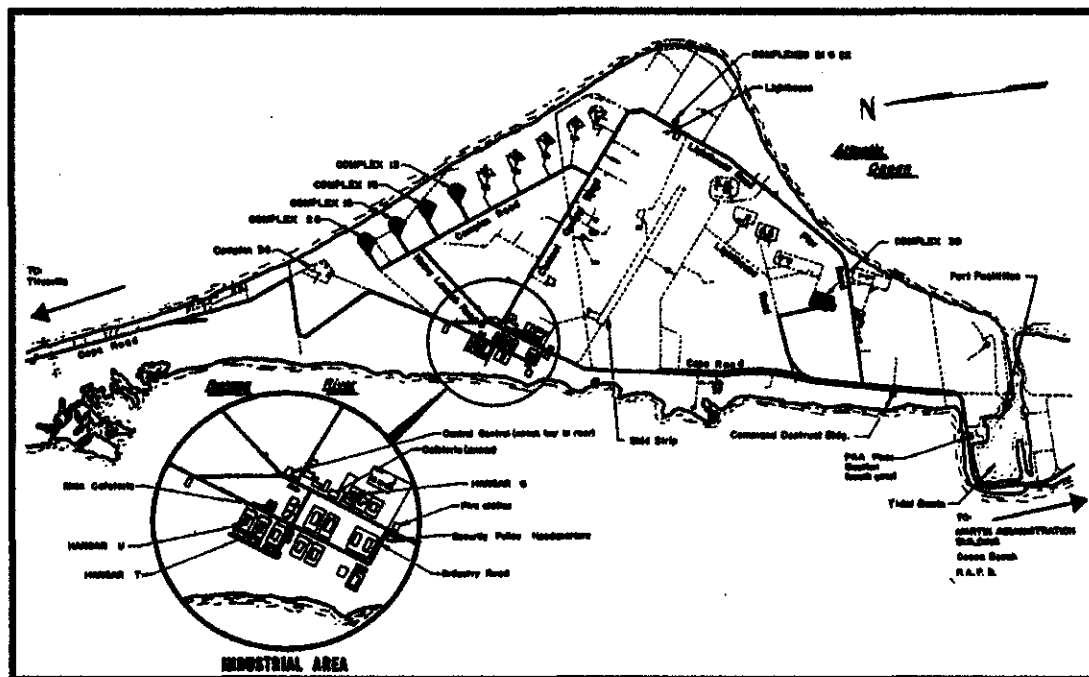
<sup>25</sup> Ibid., 43.

<sup>26</sup> Ibid., 6.

<sup>27</sup> Johnson Controls was awarded the launch base support contract in the late 1980's.

<sup>28</sup> "Cape History: Establishment of the Eastern Test Range."

As the missile program progressed at Cape Canaveral, the missiles became more sophisticated and also more powerful. It became apparent that the hangars used to assemble the missiles were dangerously close to the launch pads. In the mid-1950's, with safety considerations in mind, the Department of Defense decided to construct new missile development facilities at the Cape.<sup>30</sup> This led to the development of the Industrial Area.



## The Industrial Area

The Industrial Area, located next to the Banana River, midway between the southern and northern boundaries of the Cape, began to take shape in 1954-55. The Industrial Area was comprised of missile assembly buildings, shops, chemical storage areas, standards laboratories, heating plants, a cafeteria, a fire station, operational buildings, emergency power plants, and other miscellaneous utilities and structures. Contractors constructed the first assembly hangar in the Industrial Area, Hangar I, in 1955.<sup>31</sup> Other hangars were eventually built and since the mid-

<sup>29</sup> Barton and Levy, 6.

<sup>30</sup> Ibid., 43.

31 Ibid.

1950's the majority of vehicles launched from the Cape have been assembled at the hangars located in the Industrial Area.

### Later Construction

Development and construction continued at Cape Canaveral during the remainder of the 1950's and 1960's. After 1953, launch facilities were constructed primarily to support the intermediate range ballistic missile and intercontinental ballistic missile programs. In 1957, construction of the Mission Control Center along Flight Control Road began. The center took over flight control when the rocket left the pad and maintained it through splashdown. This function was later transferred to the Johnson Space Center in Houston in 1965.<sup>32</sup>

In August of 1961, the National Aeronautics and Space Administration (NASA) and the Department of Defense chose a section of Merritt Island (across the Banana River, three miles west from Cape Canaveral) as the launch center for the Manned Lunar Landing Program. This would be the site of the John F. Kennedy Space Center, owned and operated by NASA. During the period of the land acquisition and development, NASA built and modified a number of existing Air Force launch and support facilities at Cape Canaveral to carry out manned and unmanned space programs.<sup>33</sup>

A new period of construction began at Cape Canaveral in 1962 when the Air Force began its Titan III program at the installation. Due to safety considerations and area size requirements, Air Force contractors constructed facilities for this program on dredge spoil in the Banana River about a mile from the west side of the Cape. New missile handling technology, engineering, and launching techniques characterized the Titan III Program. Utilizing a concept known as Integrate-Transfer-Launch (ITL), the new Titan III facilities allowed for off-pad assembly of the missile, integration of the boosters, payload checkout and rail transport to one of two launching pads, all while the missile was in a vertical position. The ITL approach enabled the Air Force to obtain a high launch frequency without requiring additional launch pads.<sup>34</sup>

The Titan III facilities, completed in 1964, included two launch complexes (40 and 41), special assembly buildings (including the Vertical Integration Building), and the first rail line at Cape Canaveral. Since this period, construction at Cape Canaveral has been limited to modifying various complexes and facilities, providing additional storage, assembly and checkout buildings and adding a central heating plant in the Industrial area.<sup>35</sup>

By 1966, activities at Cape Canaveral had reached their peak and in the years following there was a gradual decline in operations. Most of the activity had shifted to the Kennedy Space Center in conjunction with NASA's effort to land a man on the moon. The Air Force deactivated or put on stand-by the launch complexes and support buildings at Cape Canaveral that had served their purposes and were either not adaptable to other uses or not maintainable for economic reasons.

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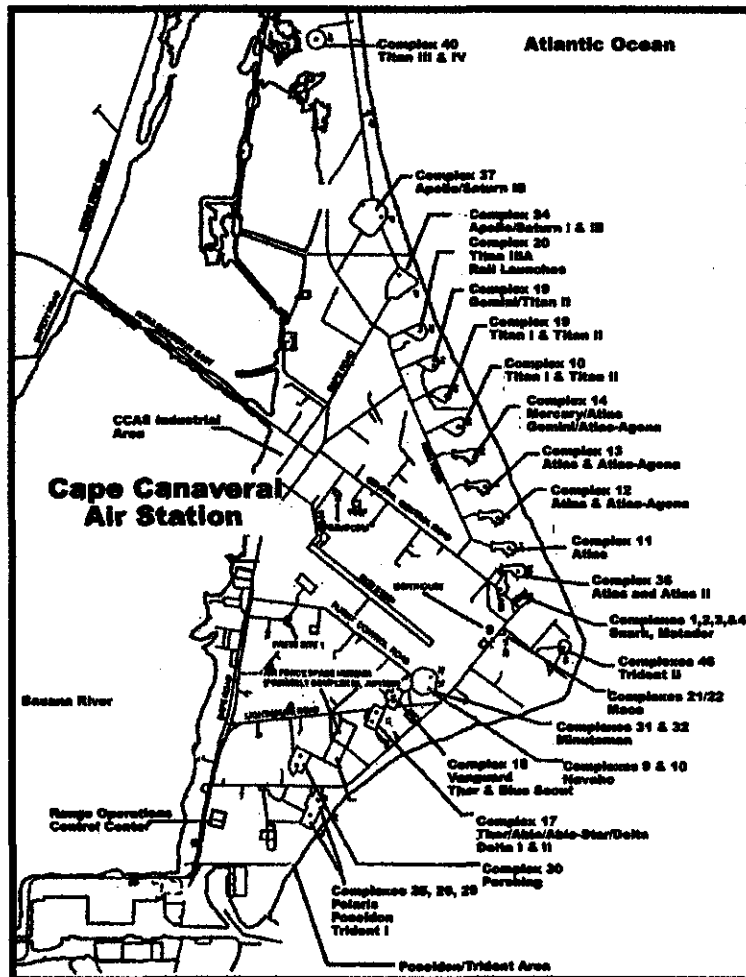
<sup>32</sup> Man In Space: Study of Alternatives (United States Department of the Interior, National Park Service, 1987), 35.

<sup>33</sup> Master Plan of the Cape Canaveral Missile Test Annex, 1.

<sup>34</sup> Ibid., 2.

<sup>35</sup> Ibid.

By the late 1960's, there were three primary launching zones at Cape Canaveral. At the point of the Cape were complexes 1, 2, 3, 4, 21/22 and 43. Except for complex 43, which supported weather rocket launches, these complexes had generally been used for various winged missile programs (such as Snark, Bomarc, Matador, Bull Goose, and Mace). Above the point of the Cape were eleven complexes situated in a line along ICBM Road. These complexes supported Atlas, Titan, and Saturn launches. Complexes 5/6, 9, 10, 17, 18, 25, 26, 31, and 32 were located under the point of the Cape. These sites had been built to support Redstone, Navaho, Thor, Blue Scout, Vanguard, Polaris/Poseidon, and Minuteman launches.



**Map showing the many types of missile launches supported by CCAS complexes**

## Missile Types

Designs for long-range missiles generally fall into two basic categories: aerodynamic cruise, or “winged” missiles; and the more advanced ballistic missiles. Cruise missiles, resembling unmanned airplanes, require oxygen to support engine combustion and are therefore restricted to the earth’s atmosphere. Ballistic missiles, on the other hand, carry their own oxygen source allowing them to travel beyond the earth’s atmosphere. Faster and more effective than cruise-type missiles, ballistic missiles travel in long arcing trajectories before striking their targets. Ballistic missiles themselves are further divided into two basic types: intermediate range ballistic

<sup>36</sup> Ibid.

missiles (IRBM's) and intercontinental ballistic missiles (ICBM's). The range of an IRBM can be as great as 1,500 miles while the range of an ICBM can be well over 5,000 miles.

### **Early Missile Research and Development**

While the Army was beginning to test-launch captured German V-2 rockets at the White Sands Proving Ground in 1946, the Army Air Force (the immediate predecessor of the Department of the Air Force, established in 1947) began funding its first long range missile development studies. In January of that year, engineers from the Consolidated Vultee Aircraft Corporation (Convair) presented the AAF with two design proposals for a missile capable of carrying a 5,000 pound warhead over a range of between 1,500 and 5,000 miles. One design was for a cruise-type missile and the other for a ballistic missile. AAF officials awarded Convair a study contract in April 1946.<sup>37</sup> Headed by the Belgian-born engineer Karl Bossart, the Convair effort became known as Project MX-774. In order to collect the necessary data, Bossart gained permission to build ten test vehicles. Funding cutbacks soon forced Bossart to abandon the cruise missile design and concentrate solely on the ballistic missile design. Bossart and his team concentrated their efforts on improving the structural design and performance of the German V-2 rocket but continued funding cutbacks forced the cancellation of the program in July 1947. Even though funding for the project was terminated, the AAF allowed Bossart and his team to use their remaining unexpended funds to complete and flight test three vehicles. These flight tests, conducted at the White Sands Proving Grounds between November 1947 and May 1948, validated Bossart's design changes.<sup>38</sup> Later ballistic missile programs benefited from information gained during this project.

In the late 1940s, the United States drastically reduced its defense spending as the nation adjusted back to a peacetime economy. The reductions forced the Air Force to decide between developing either cruise-type long range missiles or ballistic long range missiles. Air Force officials decided to pursue development of the cruise-type missiles on the grounds that this type would become operational sooner than the expected ten-year time-frame necessary for the development of an operational ballistic missile.<sup>39</sup> In the late 1940s and early 1950s the Air Force began to invest heavily in the development of several cruise missiles. These included the Matador, Snark, and Navaho missiles. The Army, meanwhile, continued its work with the V-2

### **Early Missile Testing At CCAS**

The Army was the first service to conduct a missile launch at Cape Canaveral. The missile was Bumper No. 8, a captured German V-2 rocket with a WAC-Corporal second stage. The launch took place on July 24, 1950 at Complex 3. An Army-General Electric Corporation team launched the rocket under primitive conditions, fueling the rocket directly from tank trucks and using an old Army tank as the blockhouse to control the launch.<sup>40</sup> The rocket, whose primary mission was to prove the feasibility of separating stages while in flight, traveled about 190 miles

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<sup>37</sup> Neufeld., 45.

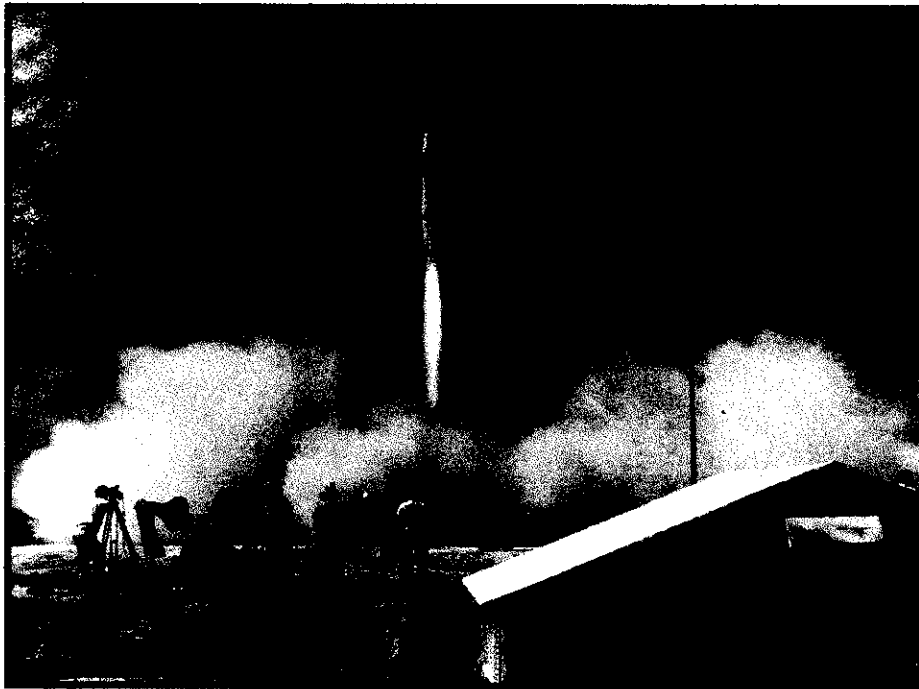
<sup>38</sup> Ibid., 48-49.

<sup>39</sup> Ibid., 48.

<sup>40</sup> From Sand To Moondust, 9.

down the range. The Army conducted four additional Bumper launches at Complex 3 in 1950 and 1951. All of these Bumper rockets were assembled from captured German V-2 rockets.<sup>41</sup>

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Photographers take pictures of the Bumper No. 8 launch

Aside from the Army Bumper launches, the majority of launches at Cape Canaveral in the early 1950s were Air Force winged missile launches. The first Air Force launch at the Cape occurred on October 25, 1950 when a team launched a Lark interceptor missile. The Lark had first been used by the Navy against Japanese aircraft during World War II. The Air Force's Lark flight lasted less than two minutes and covered only one mile. The Air Force continued to launch Larks at the Cape until 1953.<sup>44</sup>

<sup>41</sup> Barton and Levy, 12.

<sup>42</sup> From Sand To Moondust, 9.

<sup>43</sup> Barton and Levy, 12.

<sup>44</sup> "Lark," The Range Quarterly, September 1965, 3. The Air Force's Lark launches at Cape Canaveral served primarily as training vehicles for its Bomarc missile program.

The tactical Matador winged missile was the first Air Force missile program to become operational after being tested at Cape Canaveral. It was also the first missile to be successfully tracked by the downrange station on Grand Bahama Island. The Air Force conducted the first Matador launch from the Cape on June 20, 1951. Over the next eleven years, the Air Force conducted a total of 286 Matador launches from Complexes 1-3.<sup>45</sup>



Snark winged missile during a test launch

The Air Force's Snark missile was a surface-to-surface pilotless bomber with a range of over 5,000 miles. It was the first and only long range intercontinental winged missile. Launched from Complexes 1 and 2 between August 29, 1951 and December 5, 1960, the Snark made 97 downrange flights. Although the Snark was the first missile to be tracked by the downrange stations at Antigua and Ascension islands, many of the Snark flights were unsuccessful, ending up in the Atlantic Ocean. Despite the many mishaps during testing, the Snark achieved a number of "firsts". These included being the first missile to return and land at Cape Canaveral's skid strip, the first missile to be equipped with a ballistic nose that separated from the missile and fell on its target, and the first missile to use a stellar guidance system.<sup>46</sup>

In August 1955, the Air Force began the test phase of its Navaho program at Cape Canaveral. The Navaho, launched from Complexes 9 and 10 through January 1959, was a surface-to-surface missile intended as an intercontinental strategic weapon. It was carried aloft, piggyback fashion, by a liquid-fueled booster. Although the Air Force eventually canceled the program, the Navaho pioneered the development of inertial guidance systems and large rocket engines.

Other winged missiles tested by the Air Force at Cape Canaveral included the Mace, the Bomarc and the Bull Goose. The Mace, an improved version of the Matador, made 44 flights from Complexes 21 and 22 between October 29, 1959 to March of 1962. The Bomarc and the Bull Goose were defensive winged missiles. The Bomarc was designed to intercept and destroy enemy aircraft and the Bull Goose was a diversionary missile designed to confuse enemy air and ground forces. The Air Force first launched the Bomarc from Complex 4 in September of 1952. The Air Force tested the Bull Goose at Complexes 21 and 22 between March of 1957 to December of 1958.<sup>47</sup>

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<sup>45</sup> Barton and Levy, 12.

<sup>46</sup> Ibid., 12, 15.

<sup>47</sup> Ibid., 15.

### United States Ballistic Missiles

In the early 1950s, the U.S. Congress began to reassess the military cutbacks of the late 1940s. As U.S. troops fought in Korea, Congress increased funding for military projects. The Air Force took advantage of the increased funding and initiated a long range missile study, contracting Convair to carry out the effort. Designated Project MX-1593, this effort later became known as Project Atlas, a ballistic missile development project. The Air Force began funding further studies of the Atlas ballistic missile design in 1952. This funding, however, remained very low compared to the funding for the Air Force's cruise missile programs.<sup>48</sup>

While the Air Force Atlas ballistic missile program proceeded slowly, the Army was making significant progress in ballistic missile development. The Army had moved its team of German scientist working at White Sands to the Redstone Arsenal in Huntsville, Alabama in 1951. This team developed the Redstone missile. The Army began testing the Redstone at Cape Canaveral in 1953, the first launch occurring on August 20 at Complex 4. This was the first ballistic missile launch at Cape Canaveral. The Army continued launching Redstones at Cape Canaveral throughout the mid-1950s. In 1956, the Redstone became the first ballistic missile to be deployed in the field by U.S. troops and in 1958 the United States placed the Redstone in the North Atlantic Treaty Organization (NATO) arsenal.<sup>49</sup>

Although the Redstone was a ballistic missile, it had a maximum range of only 200 miles and served merely as an extension of the Army's artillery. The Department of Defense desperately desired a long-range missile that could reach Soviet targets when launched from U.S. soil. Early ICBM designs, however, called for giant, impractical missiles. These designs were based on the thrust requirements necessary to loft the heavy atomic warheads being produced at the time. Even if such a missile could be produced, considerable gains in guidance system technology would be necessary to make the missile accurate enough to be effective. Several important developments in the early 1950s, however, significantly impacted on ballistic missile design requirements. The first was the detonation of the world's first thermonuclear device by the United States in 1952. This event paved the way for development of the powerful hydrogen bomb. Soon after the detonation, the Atomic Energy Commission (AEC) predicted that the production of smaller nuclear warheads with tremendous destructive potential would soon be feasible. Smaller, yet more powerful warheads would solve many of the problems associated with missile weight and would also eliminate the need for pinpoint accuracy. This news, combined with intelligence reports indicating that the Soviet Union was making significant progress in developing both long-range missiles and thermonuclear warheads, prompted a reexamination of the United States' strategic missile programs.

The Air Force convened a panel of leading U.S. scientists in 1953 to examine the Snark, Navaho, and Atlas missile programs. Known as the Teapot Committee, the panel's report, submitted in February 1954, contained recommendations for relaxing performance requirements for long-

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<sup>48</sup> Neufeld, 241.

<sup>49</sup> "Redstone," The Range Quarterly, September 1965, 7. In the mid-1960's, the Army replaced the Redstone missile with the Pershing missile. The Army tested the 100-400 mile-range Pershing missile at Cape Canaveral between February and April 1963.

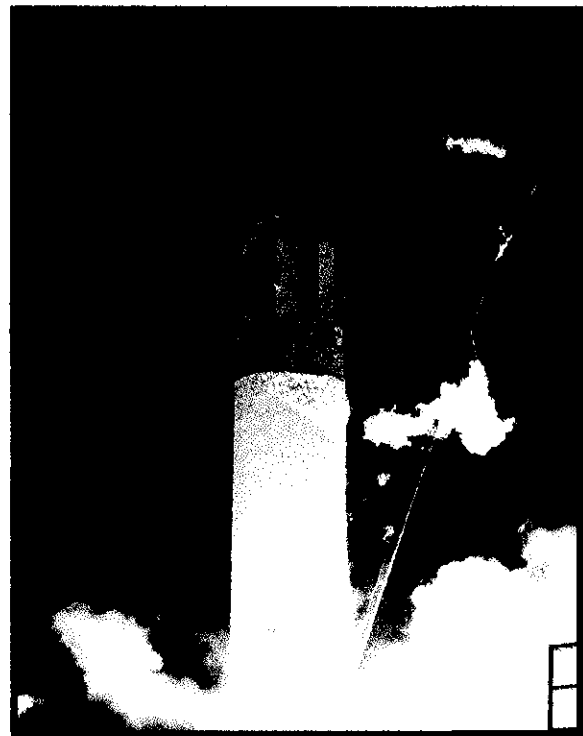
range missiles (based on the new, lightweight, high yield thermonuclear weapons) and accelerating the development of the Atlas ICBM.<sup>50</sup> These recommendations received the approval and support of high ranking civilian and military leaders during the following months. Air Force officials, and in particular Trevor Gardner, Special Assistant for Research and Development, began campaigning vigorously to convince Congress and the President of the urgency of ICBM development. These efforts paid off in 1955 when President Eisenhower assigned highest national priority to the ICBM development program.

Air Force officials originally hoped to achieve operational capability with the Atlas by 1960. As a hedge against failure in the Atlas program, however, the Air Force initiated a second ICBM development program in 1955. This alternate ICBM became known as the Titan. By 1958, the Air Force began funding development of yet another ICBM, the Minuteman. The three-staged Minuteman was a solid-fueled ICBM designed for instantaneous launch from a heavily protected underground silo.

As the pace of the Air Force ICBM program quickened, intelligence reports indicated that by 1960 the Soviet Union would likely have a number of operational ICBMs armed with nuclear warheads. Fearing the U.S. would not be ready to match that threat, Department of Defense officials decided that an IRBM should be developed and based in Europe to act as a stopgap measure until a sufficient number of American ICBMs became operational. After it was concluded that an IRBM with a 1,500 mile range could be developed in a relatively short time, the Joint Chiefs of Staff granted approval in 1955 for two IRBM programs - the Air Force Thor IRBM program and the Army/Navy Jupiter IRBM program. Both programs advanced simultaneously, in direct competition with each other.<sup>51</sup>

### **IRBM Programs**

The Army was the first service to test launch an IRBM at Cape Canaveral. This occurred on March 14, 1956 when a modified Redstone with Jupiter components lifted off the pad at Complex 6. The first Jupiter IRBM launch occurred at Cape Canaveral one year later. The Army conducted a total of 65 Jupiter launchings between March of 1956 and January of 1963 at Launch Complexes 5/6 and 26.<sup>52</sup> The Jupiter became operational in 1960. Although



**Launch of a Jupiter IRBM in 1958**

<sup>50</sup>Neufeld, 99-103.

<sup>51</sup>Ibid., 143-148. The IRBM programs were assigned equal priority with the ICBM program in January 1956.

<sup>52</sup>Ibid.

developed by the Army, it was the Air Force that actually gained operational responsibility for the weapon system. This situation came about in November 1956 when Secretary of Defense Charles Wilson issued a memorandum that divided responsibilities for research and development of ballistic missiles among the armed services. Wilson restricted the Army to developing weapons with ranges of 200 miles or less. At the same time, Wilson assigned sole responsibility for the development and deployment of IRBMs and ICBMs to the Air Force. The Navy received responsibility for developing ship-based IRBM systems.<sup>53</sup> The Army completed the development of the Jupiter IRBM and then turned it over to the Air Force for deployment.<sup>54</sup> The Air Force had operational Jupiter IRBM squadrons in Italy and Turkey by mid-1962.

The Navy initially took part in the development of the Jupiter IRBM with hopes of converting the missile for use on submarines. However, the Navy eventually determined that the liquid fuels of the Jupiter were too volatile and unpredictable to be carried aboard a submarine. In 1956, the Navy withdrew from the Jupiter project and began developing the solid-fueled Polaris IRBM.<sup>55</sup> The Polaris was designed to be launched from submarines whether the submarine was surfaced or submerged. The Polaris program began at Cape Canaveral in 1957 with the construction of Launch Complex 25. While construction of Complex 25 was underway, the Navy conducted its first Polaris launch at the Cape at Complex 3 on April 13, 1957. The first launch at Complex 25 occurred on April 18, 1958.<sup>56</sup> The Polaris became operational in 1960 although the Navy continued test launching versions of the missile at Cape Canaveral through the 1970s. In 1968, the Navy began testing its second generation Poseidon Ship-Launched Ballistic Missile (SLBM) at Cape Canaveral and in 1978 the Navy began its Trident SLBM program at Cape Canaveral.<sup>57</sup>

The Air Force Thor IRBM program began at Cape Canaveral in 1956 when the Air Force initiated construction of Complexes 17 and 18 (Pad B). The first Thor launch occurred at Cape Canaveral on January 25, 1957 at Complex 17. Unfortunately, the missile exploded and burned on the pad. Three more mishaps followed until finally, on September 20, 1957, the Thor completed a fully successful test launch. The Air Force conducted the research and development testing phase of the Thor program at Cape Canaveral and the operational testing phases of the program at Vandenberg Air Force Base, California. Such was the case with the Air Force Atlas, Titan, and Minuteman ICBM programs as well. The Thor became operational in May of 1960. By the end of that year, the Air Force had deployed four squadrons in England with the Royal Air Force. The Air Force began to phase out these Thor squadrons in 1962 and 1963 as its Atlas and Titan ICBM sites became operational. Because of its reliability and versatility, the Thor continued in service as the booster for a wide variety of space missions.<sup>58</sup>

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<sup>53</sup> Barton and Levy, 17.

<sup>54</sup> The Army did continue to develop the Jupiter as a space booster.

<sup>55</sup> Neufeld, 143-148.

<sup>56</sup> Chronology of the Joint Long Range Proving Ground, Florida Missile Test Range and Atlantic Missile Range, 1938-1959, History Office, 6550th Air Base Group, Air Force Eastern Test Range (Air Force Systems Command), 105, 111.

<sup>57</sup> In order to service its missile launches, the Navy built a complex at the south end of the Cape which included launch complexes, missile assembly and checkout facilities, administrative buildings, and a Navy pier facility at Port Canaveral.

<sup>58</sup> From Sand to Moondust, 15.

### Intercontinental Ballistic Missiles

At the same time the Air Force was developing its Thor IRBM, it was also making significant headway in its ICBM programs. The Atlas research and development testing program began on June 11, 1957 at Cape Canaveral. The Air Force conducted Atlas test launches at Complexes 11, 12, 13, and 14 through 1962. During the course of the Atlas program, the Air Force tested several models of the missile. These models were designated series A through F. The Air Force eventually stationed the D, E and F models, equipped with warheads and inertial guidance systems, at bases around the country as part of the United States' national defense arsenal. At one point, a total of 129 Atlas ICBMs were on strategic alert. The Air Force phased out its Atlas arsenal in 1964 and 1965 following the development of the Titan II and Minuteman ICBMs. Similar to the Thor, the Atlas also remained in service as a booster for America's manned and unmanned space missions.



Atlas ICBM in its Mobile Service Tower

The Air Force first tested its Titan ICBM at Cape Canaveral on February 6, 1959. Twenty of the first twenty-five Titan launches were completely successful. The Air Force declared the Titan ICBM operational in December of 1961 and by the end of 1962, six Titan squadrons were operational at five western Air Force bases. The first launch of the Air Force's second generation Titan, the Titan II, occurred on March 16, 1962 at Cape Canaveral. The Titan II, America's largest ICBM, was capable of carrying a heavier load than Titan I, used an inertial guidance system rather than a radio guidance system, and had the capacity to be launched from a silo. The Air Force declared the Titan II operational in December of 1963. Titan II was deployed at three Air Force bases and was also used as the booster for Project Gemini. The Air Force tested both Titan I and II missiles at Complexes 15, 16, 19 and 20. The Air Force also developed a Titan III, but this missile was not a weapon system. It was developed as a standardized launch vehicle for space programs. The Air Force first launched its Titan III vehicle on June 18, 1965. The Air Force used Complexes 40 and 41 (Complex 41 is located at the Kennedy Space Center) for the Titan III development program.<sup>59</sup>

Liquid propellants fueled most of the early weapons systems developed at Cape Canaveral. The Minuteman, the first multi-stage solid-fueled ICBM, was designed around the concept of instantaneous response to enemy attack. It was lighter, smaller, simpler and less expensive than the Atlas and Titan ICBMs. The Air Force eventually developed and test launched three versions of its Minuteman ICBM. Complex 31 hosted the first Minuteman launch on February 1, 1961.

<sup>59</sup> Ibid., 19.

The Air Force test launched its Minuteman I, II and III ICBMs at Complexes 30, 31 and 32 at Cape Canaveral through December of 1970.<sup>60</sup> The Air Force first deployed Minuteman ICBMs at its bases in 1962. These missiles eventually became the backbone of the nation's strategic land-based nuclear missile force.

### **Beginnings of the United States Space Programs**

The official beginnings of the United States space program can be traced back to 1955 when President Eisenhower announced that the United States would launch a small, unmanned Earth-circling scientific satellite as part of the nation's participation in the International Geophysical Year (IGY).<sup>61</sup> While planning for the IGY late in 1954, the International Scientific Committee discussed satellite vehicles as a way of obtaining information about the upper atmosphere. The IGY provided a perfect opportunity for the United States to start a satellite program that would not appear to be motivated by military considerations. In reality however, military leaders in the United States were extremely interested in developing a military space program. Although the Air Force, Army, and Navy all had been conducting upper air research programs of varying magnitude, none of the services had initiated any major efforts to start a satellite program by the early-1950s.

President Eisenhower's announcement concerning the IGY prompted all three United States armed services to begin devising plans for a satellite program. By April, three separate plans had emerged. The first was a joint effort by the Army and Navy designated Project Orbiter. This plan called for placing a simple uninstrumented satellite into orbit utilizing an Army Redstone booster. A second plan by the Navy, eventually designated Project Vanguard, involved using a Navy Viking rocket as the first-stage of a three-stage rocket. The Air Force's plan recommended using an Atlas coupled with an Aerobee-HI second stage.

Faced with these three plans, the Department of Defense set up a special advisory group to review the proposed satellite programs and to make recommendations. Although favoring the use of the Atlas, the committee eventually decided that the Navy program had the best chance of placing the most useful satellite into orbit within the IGY without interfering with the priority of ballistic missile development. As a result, the Navy was given permission to proceed with its Project Vanguard.

Even after the Department of Defense advisory group announced their official support for the Vanguard program, the Army continued to push its own proposed satellite program. Although the proposal was continuously rejected, the Army Ballistic Missile Agency continued to claim it could launch a satellite on only four months notice. The Army's persistence would eventually pay off..

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<sup>60</sup> Ibid., 20.

<sup>61</sup> The IGY extended from July 1957 to December 1958.

In August 1957, the Soviet Union announced that they had successfully launched a multi-stage long range ballistic missile that had reached a "very high, unprecedented altitude."<sup>62</sup> The Soviets followed this launch with an even more impressive feat. On October 4, 1957, the Soviets shocked the world by placing Sputnik, the first man-made satellite, into orbit with one of their rockets. They quickly followed this launch with another the following month. On November 3, a Soviet rocket placed the 1,120-pound Sputnik 2 satellite, carrying a live dog, into orbit. The Sputnik launches focused public attention on the United States' own fledgling missile and space programs. Reacting to the public furor created by the Sputnik launches, Congress increased funding for ICBM development while the Department of Defense pushed hard to match the Soviet feat by placing its own satellite into orbit.

While the Soviet's were successfully placing satellites into orbit, the Navy satellite program was experiencing many problems. The Vanguard launch vehicle blew up on its pad several times during a string of failed launch attempts. This was all the more embarrassing for the United States given the spectacular success of the Sputnik launches. While the Navy worked frantically to conduct a successful launch, the Army beat them to it. After the Sputnik launches, the Secretary of Defense gave approval to the Army to proceed with its satellite program. Eighty-four days later, on January 31, 1958, an Army team succeeded in placing the United States' first artificial satellite, Explorer I, into orbit using a modified Jupiter missile known as Juno I. This historic launch occurred at Complex 26. The Vanguard team finally succeeded in placing a satellite into orbit on March 17, 1958. The three-pound Vanguard I satellite, launched from Complex 18, studied temperatures and upper atmosphere conditions and also revealed the earth to be slightly pear-shaped.<sup>63</sup>

### **U.S. Military Space Program**

The Vanguard and Explorer launches were early efforts to place fairly primitive scientific satellites into orbit. The Department of Defense, however, gained valuable experience in satellite launch techniques as a result of these early efforts. Eager to build upon that experience, Department of Defense officials soon began planning the development of satellites that could be used specifically for military purposes. Although there had been interest among the armed services in developing reconnaissance satellites as far back as 1945, several obstacles delayed their development. Chief among these were the considerable technological challenges posed by achieving and maintaining orbit and the problems of data transmission.

Initially, the development of military satellites did not receive a high priority because the Department of Defense focused its attention on the development of operational long range missiles. By the mid-1950s, however, when it became clear that the Soviet Union would soon have numerous operational ICBM sites posing a threat to the security of the United States, American leaders quickly realized the importance of identifying the characteristics and location

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<sup>62</sup> Carl Berger and Warren S. Howard, History of the 1st Strategic Aerospace Division and Vandenberg Air Force Base, 1957-1961, (Vandenberg Air Force Base, California: Headquarters, 1st Strategic Aerospace Division, April 1962), 8.

<sup>63</sup> C.W. Scarboro, Twenty Years in Space: The Story of the United States' Spaceport (Cape Canaveral, FL: Scarboro Publications, 1969), 155.

of those weapon systems. A 1956 study by the Research and Development Corporation (RAND), partially sponsored by the Central Intelligence Agency (CIA), recommended that the Air Force undertake "at the earliest possible date completion and use of an efficient satellite reconnaissance vehicle as a matter of vital strategic interest to the United States."<sup>64</sup>

In response to this study, the Air Force began calling for proposals from industry for the development of a photographic reconnaissance satellite. Two basic types of satellite systems were subsequently proposed. One was a "non-recoverable" radio-relay reconnaissance system in which television cameras aboard a satellite would photograph ground targets, store the imagery on tape, and then relay the images to ground receiving stations when the satellite passed close enough overhead. The second type of satellite featured a "recoverable" system in which a capsule loaded with exposed film would be ejected from its satellite and return to earth where it would then be recovered. The Air Force awarded the Lockheed Corporation a contract to develop both types of satellites in October 1956. The project became known as WS-117L (Weapon System-117L).<sup>65</sup>

By 1958, the National Security Council assigned highest priority status to the development of an operational reconnaissance satellite. In November of that year, the Department of Defense announced plans for its WS-117L program, revealing that it would consist of three separate systems: DISCOVERER, SENTRY (later called SAMOS), and MIDAS. The first two were reconnaissance systems and the latter was the nation's first ballistic missile early warning satellite system. The Air Force conducted launches under these programs, using Thor and Atlas boosters coupled with various upper stages, throughout the 1960s and beyond. All of the DISCOVERER and SAMOS launches occurred at Vandenberg Air Force Base. Cape Canaveral supported two of the first three MIDAS launchings in February and May 1960.

The United States' military satellite launchings did not go unnoticed in the Soviet Union. On several occasions the Soviets complained bitterly about the satellites. In light of statements by the Soviets on the illegality of such activities and the increasingly credible threat to shoot U.S. reconnaissance satellites down, officials in the Kennedy administration decided to drastically curtail any official publicity concerning the United States' military satellite programs. By 1962, all military launches were classified as secret. The national reconnaissance effort continued although henceforth it was conducted under the highest degree of official secrecy.<sup>66</sup> Government officials hoped that the black-out of these activities would make it much harder for the Soviets to pick out the military satellites from among the various other non-military application satellites the United States was launching.<sup>67</sup> In addition, the Kennedy administration hoped that if the Soviet

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<sup>64</sup> William E. Burrows, Deep Black: Space Espionage and National Security (New York: Random House, 1986), 83.

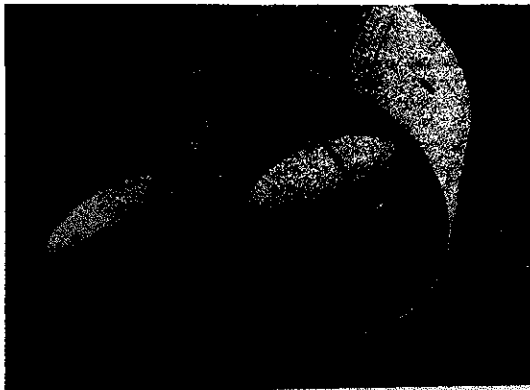
<sup>65</sup> *Ibid.*, 84. The WS-117L project was code-named Pied Piper.

<sup>66</sup> After the launch of SAMOS 5 in December 1961, officials would no longer even admit the existence of the SAMOS project (Jeffrey T. Richelson, The United States' Secret Eyes in Space: The U.S. Keyhole Spy Satellite Program (New York: Harper & Row, 1990), 53).

<sup>67</sup> Richelson, 65.

Union was not unnecessarily embarrassed in front of the other nations of the world, Soviet officials would not complain as loudly about the United States' satellite reconnaissance activity.<sup>68</sup> By the mid-1960s, reconnaissance satellites were yielding a regular supply of photographs to officials in the military services and the CIA, allowing them to stay up to date with the latest Soviet military developments. By revealing that the Soviets did not have as many ICBMs deployed as U.S. officials had previously thought, reconnaissance satellite photographs were greatly responsible for dispelling fears of the much publicized "missile gap".<sup>69</sup> Reconnaissance satellites also proved invaluable in monitoring compliance with international arms treaties such as the 1963 Nuclear Test Ban Treaty and the Strategic Arms Limitation Treaty (SALT).<sup>70</sup>

The United States has also launched other types of satellites that have military applications. These include defense communication, weather, and navigational satellite systems. Some of the important non-reconnaissance military satellite launches of the late 1960s and 1970s include the Initial Defense Satellite Communication System (IDSCS) and the Defense Satellite Communications System (DSCS II and DSCS III), the Tactical Communications Satellite system (TACSAT I), the Fleet Satellite Communications system (FLATSATCOM), the Defense Meteorological Satellite Program (DMSP), and the NAVSTAR Global Positioning System (GPS) program. All but the DMSP satellites have been launched from Cape Canaveral or the Kennedy Space Center. The DMSP as well as numerous GPS satellites have been launched from complexes at Vandenberg Air Force Base.



DSCS satellite

The military space program played a crucial role in the nation's strategic efforts during the Cold War. Satellites have kept the United States abreast of the qualitative and quantitative characteristics of the weapons systems deployed by potential adversaries. This has helped the leaders within the United States government more accurately assess potential threats to the national security and has guided them in their policy deliberations. Perhaps more importantly, the military space program made a significant contribution to the maintenance of international stability, particularly between the two nuclear superpowers of the Cold War era. Arms control

resolutions and treaties would have carried little weight had there not been satellites capable of accurately monitoring the degree of compliance among the signatory nations. In addition, by virtually eliminating the possibility of a surprise attack on the United States, reconnaissance

<sup>68</sup>Burrows, 142.

<sup>69</sup>President Kennedy used the "missile gap" argument as a campaign issue in the presidential election of 1960. He charged that the Soviet Union was gaining a strategic advantage over the United States in ICBMs. In 1961, photographs recovered from the DISCOVERER satellites reduced the estimate of Soviet ICBMs from the hundreds previously thought to ten to twenty-five, thereby dispelling the missile gap notion (Richelson, 349).

<sup>70</sup>The Nuclear Test Ban Treaty, signed by the United States, Great Britain and the Soviet Union, prohibited nuclear testing in the atmosphere, in space, and under water.

satellites have dramatically reduced the possibility that any nation might be tempted to launch such an attack.

### **United States Unmanned Civilian Space Program**

Besides spawning the nation's military space program, the early Explorer and Vanguard launches signaled the beginning of the United States' civilian space science program as well. From these pioneering scientific launches evolved programs to study the earth, the solar system, interplanetary space, the Moon, other planets and their moons, the galaxy, and ultimately, the universe. Besides enormously expanding our pool of scientific knowledge, these efforts greatly contributed to the nation's effort to send men safely to the moon and back. Information gained from the United States' various space science programs also has been applied toward practical ends, resulting in numerous application satellite programs. These application satellite programs have had a profound effect on the lives of a large proportion of the world's population.

NASA is the primary Federal agency responsible for civilian space programs. Other agencies, such as the National Science Foundation, the Department of Defense, and the Smithsonian Astrophysical Observatory, have specialized or complementary roles. After the Soviet Sputnik launches, President Eisenhower assigned temporary responsibility for the U.S. space program to the Department of Defense. The Department of Defense subsequently established the Advanced Research Projects Agency (ARPA) in February of 1958. ARPA became, in essence, the first U.S. space agency. The Eisenhower administration, however, envisioned this as only a temporary measure. The president was hoping to reach an agreement with the Soviet Union that would limit the use of outer space to peaceful purposes. Realizing that a U.S. space agency headed by the military would jeopardize this goal, Eisenhower pushed for the creation of a civilian space agency.<sup>71</sup>

The National Aeronautics and Space Act that became law on October 1, 1958 established NASA as the primary U.S. space agency responsible for developing and carrying out a national space program. NASA was created with the expressed intent that its space program be directed toward peaceful pursuits. The new civilian agency was to carry out aeronautical and space activities except those associated with defense, which were the responsibility of the Department of Defense. In anticipation of conflicts between NASA and the Department of Defense, provisions were made for mediation between the two via the President and a newly formed National Aeronautics and Space Council.<sup>72</sup>

Almost immediately, NASA initiated a National Launch Vehicle Program aimed at eliminating the proliferation and duplication of orbital launch vehicles. Consequently, five launch vehicle families evolved. These included the Scout, the Thor (which eventually evolved into the Delta), the Atlas, the Titan, and the Saturn vehicles. Separate complexes at Cape Canaveral supported

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<sup>71</sup>Congress, House, Committee on Science and Technology, Subcommittee on Space Science and Applications, United States Civilian Space Programs, 1958-1978, report prepared by Science Policy Research Division (Marcia S. Smith and others), Congressional Research Service, Library of Congress, 97th Congress, 1st sess., January 1981, Committee Print, 46-48.

<sup>72</sup>Ibid., 52.

launchings of these space boosters. The successful launch vehicle program enabled NASA and the Department of Defense to turn to each other for launch services whenever a certain payload better fit the other agency's launch vehicle, regardless of who sponsored the launch vehicle.<sup>73</sup>

NASA's civilian unmanned space program consisted of both science and application satellite and space vehicle programs. Throughout most of the 1960's, these programs were under the direction of the NASA Office of Space Science and Applications. A reorganization within NASA in 1972 resulted in the separation of the science and application satellite programs with each given its own office headed by an associate administrator.<sup>74</sup>

Many of the missions in NASA's space science program have been directly related to physics and astronomy. Although some of these missions have been suborbital, involving sounding rockets and balloons, and others have traveled as far as the Moon, the majority of NASA's physics and astronomy missions have been Earth orbital. The orbital missions have been especially rewarding to scientists because they allow measurements to be taken of phenomena well above the reach of sounding rockets or balloons. Orbital missions also have helped revolutionize astronomy by placing telescopes above the distortion caused by atmospheric turbulence and electromagnetic, infrared, and short-wave radiation.<sup>75</sup> Explorer spacecraft and several more complex orbiting observatories, such as the Orbiting Solar Observatory (OSO), the Orbiting Astronomical Observatory (OAO), the Orbiting Geophysical Observatory (OGO) and the High Energy Astronomy Observatory (HEAO), provide NASA with its principal means of conducting long-term automated investigations of the Earth, interplanetary space in close proximity to the Earth, Sun-Earth relationships, and astronomical studies of the Sun, stars, and galaxies.<sup>76</sup> Explorer missions, many of them undertaken with a significant degree of international cooperation, have been launched from both Cape Canaveral and Vandenberg Air Force Base using a variety of launch vehicles. Launches in the Explorer series began in 1958 and have continued into the 1990s. NASA launched all of its orbiting observatories from Cape Canaveral complexes in the 1960s and 1970s.

Major NASA programs involving investigations of distant interplanetary space, the Sun, the Moon, and the planets include Helios, Pioneer, Pioneer-Venus, Ranger, Surveyor, Lunar Orbiter, Mars, Mariner, Viking, and Voyager.<sup>77</sup> In supplying scientists and technicians with invaluable information and images, the spacecraft associated with these programs have dramatically increased our knowledge and understanding of our solar system and beyond.

Besides purely scientific programs, the United States unmanned space program has also encompassed a multitude of application satellite programs. Too numerous to list here in detail, these application programs include communication satellites, meteorological satellites, earth resources and environmental monitoring satellites, ocean sensing satellites, geodynamic

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<sup>73</sup>Ibid., 184.

<sup>74</sup>Ibid., 718.

<sup>75</sup>Ibid., 721.

<sup>76</sup>Ibid., 723.

<sup>77</sup>For detailed descriptions of these programs, see United States Civilian Space Programs, 1958-1978.

satellites, and navigation satellites. Application satellites have had a tremendous impact on modern life. They have linked together remote areas of the earth, exerted a lasting impact on the growth and application of the science of meteorology, and provided numerous new ways to examine and map the Earth and its oceans.<sup>78</sup> Also, there has always been a close correlation between civilian and military application satellites, especially for communications, weather and geodesy. Application satellites characterized as "military" often provide useful information to the civilian sector while "civilian" satellites, in turn, often furnish important information to the military as well.<sup>79</sup> The United States application satellite programs, combined with the nation's space science programs, have revolutionized the way we see our world and the way in which we live in it.

### **United States Manned Space Program**

In April of 1961, Russian cosmonaut Yuri Gagarin rode the Vostock 1 into an orbit around the earth, becoming the first man to do so. This achievement shook American officials into action. On May 25, 1961, in a special message to Congress, President Kennedy stated that the United States "... should commit itself to achieving the goal before this decade is out, of landing a man on the Moon and returning him safely to the earth."<sup>80</sup> Public support was widespread and Congress heartily endorsed the measure. NASA was responsible for carrying out the ambitious goal.

The American manned space program was divided into three phases: the Mercury, Gemini and Apollo programs. Cape Canaveral supported all of these phases.

### **Project Mercury**

The goals of Project Mercury were to demonstrate that it was possible for a man to tolerate what it would take to send him into space and bring him back. These included withstanding the acceleration of rocket launches, adapting to long periods of weightlessness, and then withstanding the high deceleration period during re-entry. Project Mercury had two parts, a suborbital stage and a manned orbital stage. During the first stage, NASA launched the chimpanzee, Ham, on a suborbital flight aboard a Mercury/Redstone vehicle on January 31, 1961. Other test launches utilizing primates followed. Alan Shepard became the first American man in space on May 5, 1961 when he rode aboard a modified Redstone rocket. Virgil Grissom's flight followed on July 21, 1961.<sup>81</sup> NASA launched all of the Mercury suborbital flights from Complex 5/6.<sup>82</sup>

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<sup>78</sup>For information on specific civilian application satellite programs see United States Civilian Space Programs: Volume II, Application Satellites prepared for the Subcommittee on Space Science Applications of the Committee on Science and Technology, U.S. House of Representatives, 98th Congress, 1st session, May 1983.

<sup>79</sup>For example, the Department of Defense's DMSP satellites regularly provide weather data to the National Oceanic and Atmospheric Administration (NOAA). Conversely, in March 1984, the NOAA's Landsat 4 earth resources satellite helped Department of Defense officials detect a Soviet ballistic missile-firing submarine testing equipment designed to smash through Arctic ice prior to underwater missile launch (see Burrows, supplemental photos).

<sup>80</sup>From Sand to Moondust, 29.

<sup>81</sup>Barton and Levy, 28.

<sup>82</sup>*Ibid.*, Appendix 7.

John Glenn became the first American man to successfully accomplish a manned orbital flight mission. He circled the earth three times aboard Mercury/Atlas 6 on February 20, 1962. Gordon Cooper's 22-orbit flight, ending on May 15, 1963, concluded Project Mercury. It was the fourth manned mission. The whole Mercury program lasted 55 months and led directly to Project Gemini.<sup>83</sup>

### **Project Gemini**

NASA publicly announced Project Gemini on January 3, 1962. The goal of Project Gemini was to perfect space rendezvous and docking techniques and to attempt extravehicular walks in space. The successful completion and mastering of these operations was necessary in order to move on to the next step of landing men on the moon and then recovering them. Sophisticated manned space flight was mastered during this project.

NASA used a modified Titan II as the space booster for Project Gemini and a Mercury capsule which was twice the size of earlier capsules was used to accommodate two astronauts. The first Gemini launch took place on April 8, 1964 from Complex 19. The first Gemini manned flight took place in March of 1965. There were a total of ten manned Gemini flights, placing 20 astronauts into orbit. These flights allowed the astronauts to conduct sophisticated maneuvering exercises and return back to earth safely.<sup>84</sup>

### **Project Apollo**

The goal of Project Apollo was to send a three-man spacecraft into orbit around the Moon, land two of the astronauts on the Moon while the third continued to orbit, return the two men back to the orbiting spacecraft and then return all the men safely back to earth. NASA announced on January 9, 1962 that the Saturn V rocket would be the launch vehicle. The Saturn V was a huge rocket standing about 27 stories high and capable of generating 7.5 million pounds of thrust.<sup>85</sup> NASA divided Apollo into two phases: earth orbital (unmanned and manned) and lunar. Missions were designed to test spacecraft launch vehicles, equipment and crew procedures. Tragedy struck on January 27, 1967 when an oxygen fire at Complex 34 took the lives of astronauts Virgil Grissom, Edward White and Roger Chaffee, the first casualties of the U.S. space program.



**Apollo missions placed U.S. astronauts on the moon**

Despite the tragedy, the Apollo program continued. The first Saturn V test flight took place on November 9, 1967 with the launch of Apollo 4. The first manned Apollo launch took place on September 26, 1968 when Apollo 7 put three astronauts into earth orbit. The first lunar orbiting occurred during Apollo 8 in December of 1968. Finally, on July 20, 1969, Commander Neil

<sup>83</sup> Ibid., 28.

<sup>84</sup> Ibid., 30.

<sup>85</sup> From Sand to Moondust, 29.

Armstrong became the first man ever to set foot on the moon during the Apollo 11 mission. Six additional moon missions followed. Apollo 17, launched on December 17, 1972 was the last mission in the series. The Apollo launches took place at Complex 34 at Cape Canaveral and Complex 39 at the Kennedy Space Center.<sup>86</sup>

### **Beyond Apollo**

Three other manned space missions occurred after the Apollo program, all taking place at the Kennedy Space Center. The Skylab mission began on May 14, 1973 and involved placing a large inhabitable structure into orbit around the earth for use in collecting scientific data. Apollo-Soyuz was a cooperative project between the Americans and the Russians involving the docking of two manned spacecraft in space. NASA launched this project from Complex 39 at the Kennedy Space Center. NASA first launched the Space Shuttle, the world's first reusable spacecraft, from Pad A at Complex 39 on March 12, 1981. Complex 39 continues to support Space Shuttle launches.<sup>87</sup>

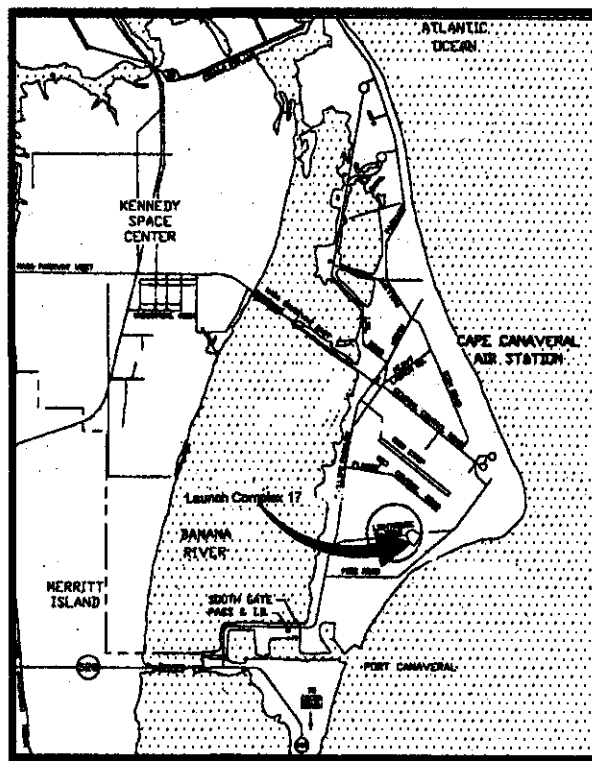
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<sup>86</sup> Ibid., 29.

<sup>87</sup> Ibid., 32.

## History of Complex 17

In preparation for the Thor IRBM research and development program, the Air Force initiated construction of Launch Complex 17 in April 1956. The Army Corps of Engineers directed the "brick and mortar" construction work on the complex. Located at the east end of Lighthouse Road south and west of the point of the Cape, Complex 17 included two launch pads (Pad 17A on the north side and Pad 17B on the south side), a single blockhouse that served both pads, and various support facilities and buildings. The major structure at each pad was a retractable gantry service tower that gave test crews access to every part of the erected missile. These service towers rolled away on rails prior to launch. The United States Steel Company of Los Angeles fabricated the service towers in sections and shipped them to Cape Canaveral for assembly.<sup>86</sup>



Location Map of Launch Complex 17

Due to the urgency of the Thor IRBM development program, the Air Force did not have time to draw up new designs for the Complex 17 blockhouse. Instead, the Air Force borrowed a set of plans from the Army for their Redstone blockhouse design and used them for the blockhouse at Complex 17.<sup>87</sup> The blockhouse, as well as Pad 17B were completed by the end of November of 1956. Pad 17A was completed in April of the following year. Construction costs for each pad totaled \$3.503 million.

## Air Force Thor Research and Development Program

The Thor IRBM was a single-stage, liquid-fueled missile. It could attain speeds of about 10,000 miles per hour, had a range of over 1,500 miles, employed an all-inertial guidance system, and was capable of carrying a nuclear warhead. The prime contractor for the Thor weapon system was the Douglas Aircraft Company. Subcontractors included the North American Aviation Company (engines), AC Spark Plug (guidance system), and the General Electric Company (nosecone).<sup>88</sup> Cape Canaveral supported the initial Thor R&D launches while Vandenberg Air Force Base, California supported operational tests of the missile, the launch facilities, and the

<sup>86</sup> Julian Hartt, *The Mighty Thor* (New York: Duell, Sloan and Pearce, 1961), 83.

<sup>87</sup> *Ibid.*, 73-74. The Army's Redstone blockhouse was located at nearby Complex 26.

<sup>88</sup> "Thor Fact Sheet," *News Release* (Office of Information Services, Headquarters, Air Force Missile Test Center, Patrick Air Force Base, February 1959).



**Construction at Launch Complex 17, 1956**

(Photograph courtesy of Mark Cleary, Chief, ESMC History Office, Patrick Air Force Base, FL)

supporting ground equipment. Vandenberg Air Force Base also supported the training of the Thor combat crews.

The Air Force began the R&D portion of the Thor IRBM program with a launch attempt at Pad 17B on January 25, 1957. It was an inauspicious beginning however, as the missile rose only 6 inches before exploding and burning. This mishap caused extensive damage to pad, including the complete destruction of the terminal room under the pad. The Air Force immediately began repairs. Part of this effort involved the installation of fire safety equipment so as to minimize damage during any future missile explosions. This equipment proved itself worthwhile as several other early Thor launches ended prematurely in fiery explosions.<sup>89</sup>

The Air Force resumed its Thor testing program in the spring of 1957 with launch attempts on April 19, May 21, and August 30 (the first use of Pad 17A). None of these launches were entirely successful. From these early failures the Air Force gathered valuable information that lead to design modifications in the missile. Finally, on September 20, 1957, hard work paid off as the Air Force conducted its first successful Thor launch at Pad 17B.

The Air Force continued conducting Thor IRBM test launches at Complex 17 until December of 1959.<sup>90</sup> In all, the Air Force conducted a total of five Thor IRBM launches at Pad 17A between

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<sup>89</sup> The Mighty Thor, 105.

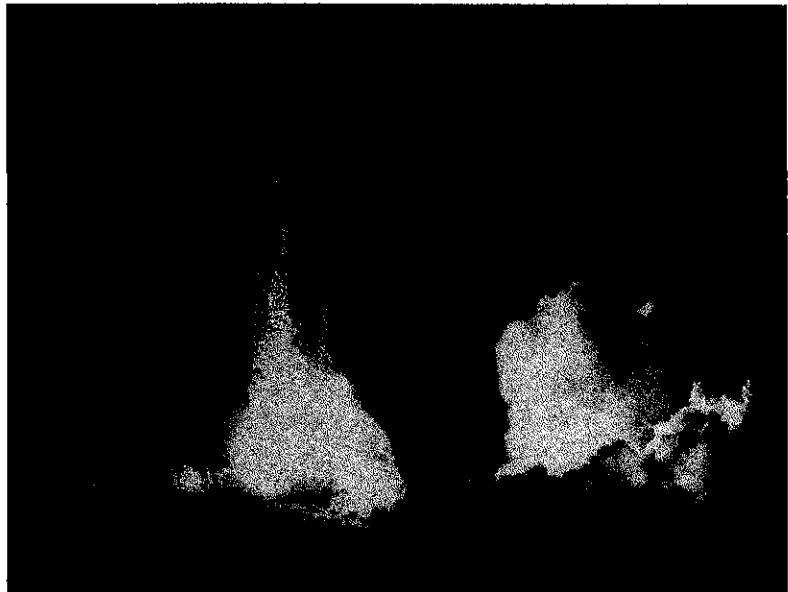
<sup>90</sup> The Air Force also conducted Thor research and development launches at nearby Complex 18 (Pad B). The Air Force conducted the last of 17 such launches at Complex 18 on February 29, 1960.

August 30, 1957 and January 28, 1958 and 26 Thor IRBM launches at Pad 17B between January 25, 1957 and December 17, 1959.<sup>91</sup> A number of these launch attempts were unsuccessful, with the missile either exploding on the pad or being destroyed in flight by the range safety officer. Overall, however, the Thor IRBM development program was a tremendous success. Test launches at Cape Canaveral and Vandenberg Air Force Base allowed the Air Force to produce a reliable IRBM weapon system. By April of 1960, the Air Force had 60 operational Thor IRBM sites in Great Britain. These missiles served as a deterrent to Soviet aggression while the Air Force was readying its operational ICBM force.

### **Thor-Able and Thor-Able-Star Launches at Complex 17**

As the Thor IRBM began to prove itself in test launches at Cape Canaveral, the Department of Defense quickly recognized the Thor's potential use as a booster for various research and satellite programs. In the spring of 1958, the Air Force began launching Thor boosters coupled with various upper stages at Launch Complex 17.

On April 23, 1958, the Air Force conducted the first of a series of nine Thor-Able launches at Pad 17A.<sup>92</sup> The purpose of these launches was to carry and test an advanced re-entry nosecone for the Atlas ICBM at the full ICBM range of 6,000 statute miles, and at



**Nighttime Thor-Able launch at Complex 17**  
(Photograph courtesy of Mark Cleary, Chief, ESMC History Office,  
Patrick Air Force Base, FL)

ICBM speeds of over 17,000 miles per hour. These tests, performed several months before the first scheduled full-range Atlas flight, helped determine the final design requirements for the nation's first ICBM. Although the launch attempt on April 23rd failed a second attempt on July 9, 1958 was successful.<sup>93</sup> The missile traveled 6,000 miles down the test range and the nosecone successfully re-entered the atmosphere.<sup>94</sup> Seven additional re-entry nose cone tests with Thor-

<sup>91</sup> "Eastern Range Launches: Sites 17A and 17B." List provided courtesy of Mark Cleary, Historian, 45th Space Wing, Patrick Air Force Base, Florida.

<sup>92</sup> The Able vehicle was a modified Vanguard second stage.

<sup>93</sup> After this launch, an article appearing in U.S. News & World Report proclaimed that the U.S. now possessed "a ballistic missile of intercontinental range, capable of reaching any point on earth from bases available in this country and abroad." This proclamation was overly optimistic however, as the Air Force admitted that the Thor-Able was not a usable ICBM ("Thor-Able: Higher, Farther-A Moon-Probing Shot Next?," U.S. News & World Report, 18 July 1958, 54).

<sup>94</sup> "Thor Fact Sheet."; "Eastern Range Launches: Sites 17A."

Able vehicles followed, the last occurring on June 11, 1959. These tests yielded valuable information about nosecone re-entry performance that later benefited the Air Force's various ICBM programs.

While the Air Force's Thor IRBM R&D program and special nosecone re-entry tests proceeded, the Department of Defense authorized the Air Force to conduct three lunar probe launch attempts. These attempts were aimed at gathering scientific data about the moon and the environment around the moon. Using the Thor-Able configuration with a solid-fuel third stage, the Air Force's Ballistic Missile Division conducted the first lunar probe launch attempt on August 17, 1958 at Pad 17A. The payload was Pioneer, a 40-pound instrumented probe that contained a scanner to photograph the backside of the moon, a magnetometer, a meteoroid counter, and several thermometers. The launch attempt started out well when the Thor-Able successfully lifted off its pad. Unfortunately after only 77 seconds of flight the vehicle exploded, destroying the payload.<sup>95</sup>

The Air Force quickly began preparations for a second lunar probe launch attempt. Before it took place, however, President Eisenhower's Executive Order 10783 transferred the lunar probe effort, along with several other space programs, from the Department of Defense to NASA. Consequently, the second and third lunar probe launches were conducted under NASA direction although the Air Force's Ballistic Missile Division continued to provide the Thor-Able launch vehicles and continued to actually conduct the launches.

The second lunar probe launch attempt took place at Pad 17A on October 11, 1958. Uneven separation of the launch vehicle's second and third stages prevented a complete success although the probe, designated Pioneer I, did reach a then-unprecedented altitude of over 70,000 miles. It also verified the existence of the Van Allen radiation belt before re-entering the atmosphere after 43 hours. The third and final lunar probe launch followed on November 8, 1958. This time the Thor-Able vehicle's third stage failed to ignite. The probe, designated Pioneer 2, returned some useful scientific data before re-entering the atmosphere.<sup>96</sup>

Four additional Thor-Able space launches took place at Pad 17A after the Pioneer 2 shot. The payloads for these launches included Explorer 6, Transit 1A, Pioneer 5, and TIROS 1 (Television Infrared Observation Satellite). The Air Force's Ballistic Missile Division provided the vehicle and conducted these launches for NASA and the Navy.

Explorer 6, launched on August 7, 1959, was a scientific satellite that measured radiation in space, mapped the earth's magnetic field, provided a crude TV image of the earth's cloud cover, and discovered a large electrical current system in the outer atmosphere.<sup>97</sup> Transit 1A, launched on September 17, 1959, was the Navy's first navigation satellite. It was designed to develop a precise and reliable means of fixing the position of seacraft, submarines, and aircraft at any time

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<sup>95</sup> A Summary of Major NASA Launches, October 1, 1958 - December 31, 1979 (KSC Historical Report No. 1, July 1980), A-9.

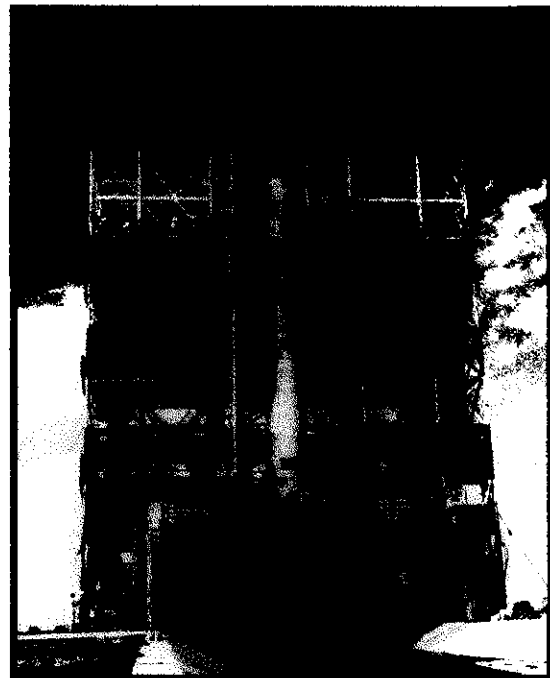
<sup>96</sup> *Ibid.*, I-34.

<sup>97</sup> *Ibid.*, I-3.

and under any weather conditions.<sup>98</sup> Pioneer 5 was a highly successful NASA interplanetary probe that explored the space between the orbits of Earth and Venus, produced the first data on the nature of interplanetary space, and established a communications record of approximately 22.5 million space miles. The Pioneer 5 launch took place on March 11, 1960.<sup>99</sup> The launch of NASA's TIROS 1 on April 1, 1960 was the first time a true meteorological satellite was placed into orbit. Weighing 122 pounds, TIROS 1 photographed cloud cover and transmitted over 22,000 photographs between April 1 and June 17, 1960.<sup>100</sup>

The first space launch at Pad 17B on April 13, 1960 saw the first use of the Thor-Able-Star vehicle. The Able-Star upper stage had a larger fuel tank than the Able upper stage and therefore did not require a solid-fuel third stage. In addition, the Able-Star was the first vehicle with shutdown and restart capabilities. The Able-Star demonstrated this capability during the April 13 launch when the Navy's Transit 1B navigation satellite was successfully placed into orbit.<sup>101</sup> Nine additional Thor-Able-Star launches at Pad 17B followed the Transit 1B launch. Most of these launches boosted either Navy Transit satellites or Army Courier active repeater communication satellites. The last Thor-Able-Star launch at Pad 17B occurred on May 10, 1962.<sup>102</sup>

The Air Force did conduct one Thor-Able-Star launch at Pad 17A. This occurred on October 31, 1962. The payload for this launch was the ANNA 1B application satellite, a joint Army, Navy, and Air Force project. ANNA 1B measured the strength and direction of the Earth's gravitational field.<sup>103</sup>



**Thor-Able Star being readied for launch  
at Pad 17B**

(Photograph courtesy of Mark Cleary, Chief, ESMC History  
Office, Patrick Air Force Base, FL)

<sup>98</sup> "United States Launches Two More Satellites," Science 22 April 1960, 1198; Space and Missile Systems Organization: A Chronology, 1954-1979 (Los Angeles: SAMSO Headquarters, Space Division, Office of History, 1979), 70. The Transit 1A satellite did not achieve orbit due to a third stage malfunction.

<sup>99</sup> A Summary of Major NASA Launches, I-36.

<sup>100</sup> Ibid., II-1.

<sup>101</sup> "Able-Star Works as Second Stage Booster," Aviation Week, 29 August 1960, 50-51.

<sup>102</sup> "Eastern Range Launches: Sites 17A and 17B."

<sup>103</sup> C.W. Scarboro, Twenty Years In Space: The Story of America's Spaceport (Cape Canaveral, Florida: Scarboro Publications, 1969), 178. The ANNA 1B followed the unsuccessful attempt five months earlier to launch the ANNA 1A satellite at Pad 17B.

### Other Thor Launches at Complex 17

The Air Force conducted a series of special launches at Pad 17B between March 24, 1964 and February 23, 1965. These launches were in support of the ASSET (Aerothermodynamic-Elastic Structural Systems Environment Tests) program. This program was designed to test high-speed re-entry glide methods and the advanced, heat-resistant metals used in the Dyna-Soar winged glider program. Dyna-Soar (for Dynamic Soaring) was a joint NASA and Air Force project aimed at developing a one-man winged space vehicle that could achieve orbit via ballistic missile lift and then return to earth by gliding and landing like an airplane, just like today's Space Shuttle. The Air Force envisaged several uses for such a vehicle including a manned orbiting reconnaissance craft, a space weapons delivery system, and an anti-satellite interceptor.<sup>104</sup>

The ASSET launches, six in all, involved scaled-down versions of the Dyna-Soar gliders being boosted to altitudes of 30-50 miles by Thor vehicles. Telemetry information from built-in transmitters provided acceleration, vibration level, pressure, temperature, and other data to a ground station before the gliders landed via parachute. Although the Dyna-Soar program was officially canceled in December 1963, the Air Force completed all of the Asset launches, gaining valuable data that later benefited the Space Shuttle program.<sup>105</sup> In the spring following the last ASSET launch, the Air Force, seeing no further military use for Complex 17, transferred the facility to NASA for its Delta space launches.

### The Delta Launch Vehicle

Since 1960, the majority of launches at Complex 17 have been Delta launches. This booster has launched a large percentage of the United States' research, weather, and communication satellites, as well as numerous scientific and military payloads. NASA and, most recently, the Air Force, have conducted Delta launches at Complex 17 and at Space Launch Complex 2 at Vandenberg Air Force Base, California.

The Delta launch vehicle family originated in April 1959 when NASA signed a \$24 million contract with the Douglas Aircraft Company (now McDonnell Douglas Aerospace Corporation) for development of a three-stage vehicle using a modified Thor booster with the two-stage Delta upper stage vehicle.<sup>106</sup> The Delta contract represented a new management concept for NASA as it was the only space booster in which NASA retained over-all technical control with no middle man, such as the Air Force, between NASA and the prime contractor.<sup>107</sup>

NASA originally planned to limit its use of the Delta vehicle to only twelve launches. However, after early launches of the vehicle demonstrated its reliability and versatility, NASA continued to

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<sup>104</sup> Frank H. Winter, Rockets Into Space (Cambridge, Mass.: Harvard University Press, 1990), 115, 118.

<sup>105</sup> *Ibid.*, 118.

<sup>106</sup> Space and Missile Systems Organization: A Chronology, 1954-1979, 66. The Delta upper stage consisted of two Vanguard rocket engines.

<sup>107</sup> "Delta Pioneers New Management Concept," Aviation Week, 9 November 1959, 26. NASA's contract with the Douglas Aircraft Company created some confusion in so far as the name of the vehicle was concerned. NASA designated the entire vehicle as Delta although in reality it was a Thor/Delta. The Douglas Aircraft Company also produced the same vehicle under a different contract for the Air Force which used the designation Thor/Delta.

place orders with the Douglas Aircraft Company for additional Deltas. The Douglas Aircraft Company, in addition to manufacturing the Delta, also performed mission analyses, test, payload integration, and launch operations for NASA's Delta launches.

From its initial configuration, the Delta has evolved through the years to meet ever increasing mission requirements. The vehicle has grown in a building-block fashion with each modification increasing the Delta's payload capacity.

The first modifications to the Delta occurred in 1962 when the Douglas Aircraft Company produced the Delta A version with an improved first stage engine and the Delta B version with a lengthened second stage that contained a higher energy propellant. The Delta C version, debuting in 1963, contained a bulbous fairing and an improved third stage motor. In 1964, the thrust-augmented Delta or Delta D utilized three solid fuel strap-on Thiokol Castor I motors. The Delta E of 1965 featured a larger payload fairing, larger diameter propellant tanks along with restart capabilities on the second stage, and a new third stage motor. This version also used more powerful Castor II strap-on solid rocket motors.<sup>108</sup>

The next major modification to the Delta occurred in 1968 when McDonnell Douglas manufactured the Delta J with a new Thiokol third stage motor. Other modifications in 1968 included lengthened first stage propellant tanks and increased diameter RP-1 tanks on the Delta L, M, and N vehicles. Beginning in 1969, the M-6 and N-6 models used six solid strap-on motors instead of only three. The L, M, N, M-6 and N-6 were commonly known as Long Tank Deltas or as Long-Tank Thrust-Augmented Deltas when the solid strap-on motors were used.<sup>109</sup> Two new series of Deltas evolved in the early 1970s. The 900 series featured nine strap-on Castor II motors, a new Titan Transtage second stage engine, and an improved precision guidance system. The 1000 series Deltas were, for all practical purposes, entirely new vehicles. All eight variations of the 1000 series incorporated some first stage changes but varied in the number of solid Castor II strap-on engines. All of these vehicles had extended booster tanks and uniform 8-foot diameter fairings thus earning them the nick-name Delta 'Straight Eights'.<sup>110</sup>

The Delta 2000 series, developed by McDonnell Douglas in the mid-1970s, utilized differing third stages and differing number of Castor II solid strap-on motors. These vehicles also all employed new first and second stage engines. The Delta 3900 series of the mid to late 1970s and early 1980s, principally the 3914 and the 3910/PAM (Payload Assist Module) were very similar to the 2900 series. The main difference was the use of nine larger and more powerful Castor IV strap-on solid motors on the 3900s as opposed to the Castor II strap-ons of the 2900s. The PAM, originally developed by McDonnell Douglas for the Space Shuttle, was a 116-foot tall third stage vehicle that transferred satellites from a low earth parking orbit to their final orbits.<sup>111</sup>

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<sup>108</sup> Steven J. Isakowitz, International Reference Guide To Space Launch Systems (Washington D.C.: American Institute of Aeronautics and Astronautics, 1991), 202-203.

<sup>109</sup> Ibid., 203.

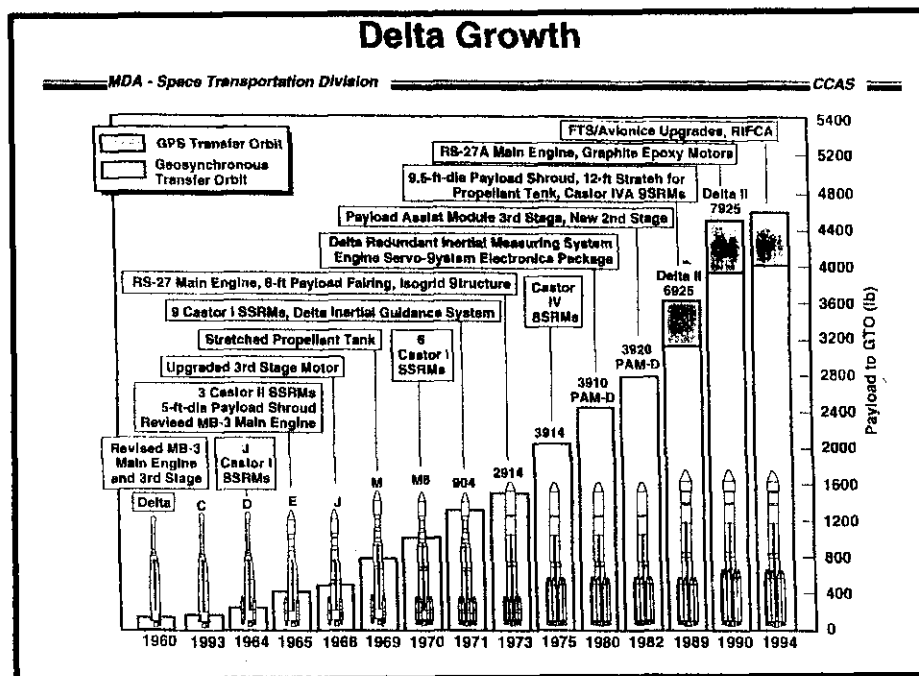
<sup>110</sup> Ibid.; "Delta Refined for Bigger Payloads," Aviation Week & Space Technology, 19 July 1971, 12.

<sup>111</sup> International Reference Guide To Space Launch Systems, 203.

The 3920/PAM Delta of the 1980s was an evolution to accommodate payloads designed for the higher capability of the Space Shuttle. McDonnell Douglas developed this version when it became apparent that the transition to the Space Shuttle would take longer than originally anticipated. The 3920/PAM featured a modified Titan Transtage second-stage engine. Other Delta models of the 1980s included the 4925 and 5920. The 4925, always coupled with the PAM, employed more powerful Castor IVA strap-on motors while the 5920 utilized a more powerful Rocketdyne first stage engine.<sup>112</sup>

With the development of the Space Shuttle, the Department of Defense initially made plans to orbit the majority of its satellites using the new versatile vehicle. However, after a string of failures in the American space program between 1985 and 1987, including the explosion of the Challenger Space Shuttle, the Department of Defense made a decision to rely on expendable space boosters, in addition to the Space Shuttle, to orbit its payloads.

In 1988, the Air Force held a competition for a medium launch vehicle that would launch the Global Positioning System (GPS) satellites. McDonnell Douglas won the contract with its Delta II series, designated 6925 and 7925. The first stage tanks of these versions are lengthened 12



The Delta booster has grown through the years to meet increased mission requirements

(Chart courtesy of McDonnell Douglas)

feet and each employs uprated motors.<sup>113</sup> After the Air Force chose Complex 17 as the launch site for the Delta II, it re-acquired that complex from the NASA in October of 1988. The Air

<sup>112</sup> Ibid.

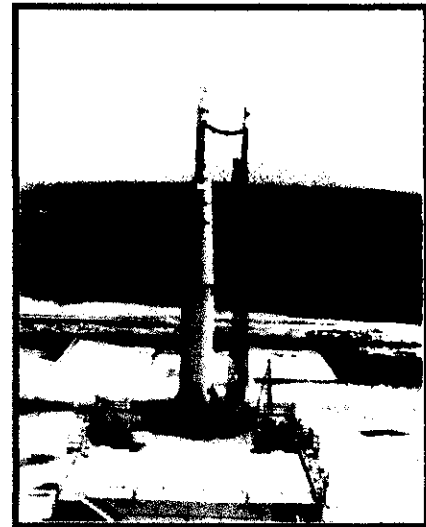
<sup>113</sup> Ibid.

Force subsequently modified the complex, including raising the complex's Mobile Service Towers by about 20 feet to accommodate the larger vehicle. Civilian customers also began signing up for Delta II launches.<sup>114</sup>

The latest evolution of the Delta is the Delta 3. McDonnell Douglas launched this program in 1995 when Hughes Space and Communications International signed a \$1.5 million contract for ten of these vehicles. Its first launch scheduled for 1998, the Delta 3 will debut a cryogenic upper stage, a larger payload fairing, larger strap-on solid rocket motors, and a new first stage fuel tank.<sup>115</sup> Complex 17 will undergo modifications to accommodate the Delta 3 launch vehicle.

### Delta launches at Complex 17

NASA's first use of its Delta vehicle occurred on May 13, 1960 at Pad 17A. This launch carried the Echo passive communications satellite. Echo was a 100-foot diameter balloon that was to reflect voice and crude television signals. The Echo never made it into orbit however, as the Delta's second stage malfunctioned. The following Delta launch, conducted on August 12, 1960 at Pad 17A, successfully boosted NASA's ECHO 1 satellite. Similar to Echo, Echo 1 was a 100-foot diameter aluminized plastic sphere. It was the world's first passive communications satellite to achieve orbit. The largest and most visible satellite at the time, Echo 1 was used as a reflecting relay for global communications experiments.<sup>116</sup> The Echo 1 launch was the first in a series of successful launches at Complex 17 that established the Delta as one of the United States' most reliable space boosters.



Delta with Echo satellite  
(McDonnell Douglas photo)

Since the successful Echo 1 launch, Complex 17 has supported 195 Delta launches (as of December of 1996) with a success rate of over 94 percent. These launches have boosted a wide variety of payloads including scientific, meteorological, communications, and military satellites. A discussion of some of the most important of these spacecraft follows.

### Scientific Satellites

Included among the scientific satellites launched at Complex 17 are the Explorer series, the Pioneer series, the Orbiting Solar Observatories (OSO) series, and the International Sun-Earth Explorer (ISEE) series.

<sup>114</sup> Information supplied by Mark Cleary, Historian, 45th Space Wing, Patrick Air Force Base, Florida. NASA also began modifying SLC-2 at Vandenberg Air Force Base in 1992 to accommodate Delta II launches.

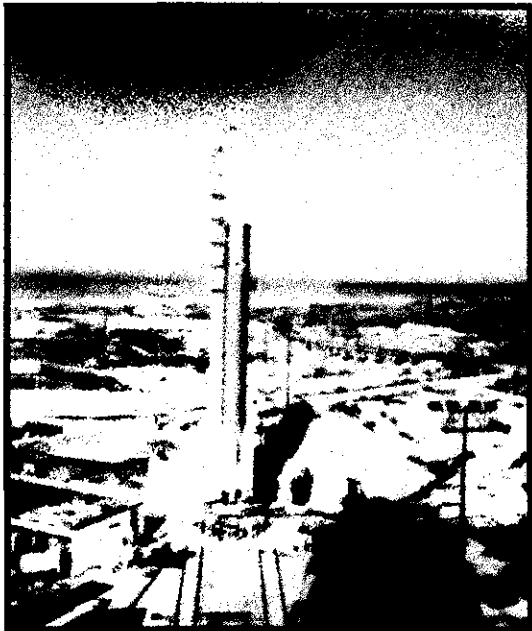
<sup>115</sup> "Delta 3 Aims at Mid-Year Critical Design Review," *Aviation Week & Space Technology*, 11 March 1996, 64;

"New Delta 3," *Ad Astra*, July/Aug 1995, 22.

<sup>116</sup> *A Summary of Major NASA Launches*, III-1.

NASA's Explorer series satellites have measured everything from the density, pressure, composition, and temperature of the upper atmosphere and ionosphere to radiation, magnetic fields, energetic particles, cosmic rays, solar plasma and solar winds in space. The first Explorer launch at Complex 17 took place on August 7, 1959. A Thor-Able acted as the booster for this payload. By December of 1996, 18 additional Explorer satellites have been launched at Complex 17 with Delta vehicles.<sup>117</sup>

NASA's early Pioneer spacecraft were lunar probes. After its two unsuccessful Pioneer launch attempts at Complex 17 in 1958, NASA attempted five additional Pioneer lunar probe launches at other Cape Canaveral launch complexes in 1958, 1959, and 1960. Beginning in March of 1960, NASA returned to Complex 17 for six more Pioneer launches. Over the next nine years, NASA successfully launched five of these six Pioneer spacecraft. Designed to gather data on solar plasma and energetic particles and magnetic fields propagated by the Sun, these spacecraft greatly contributed to NASA's investigation into the effects of solar activity on the Earth's environment.<sup>118</sup>



A Delta 1910 loaded with an OSO in 1975  
(McDonnell Douglas photo)

The OSO and ISEE spacecraft contributed greatly to NASA's increasing wealth of knowledge about our solar system. Nine OSO spacecraft, launched between March of 1962 and July of 1975, monitored the Sun's activity, particularly its production of harmful solar protons.<sup>119</sup> The ISEE satellites were a joint project of NASA and the European Space Agency. These spacecraft returned scientific data about the environment between the Earth and the Sun. NASA launched two ISEE spacecraft simultaneously on October 22, 1977 with a Delta 2914. A third ISEE spacecraft was launched on August 12, 1978 with a Delta 2914 again serving as the booster.<sup>120</sup>

Other important scientific satellites launched at Complex 17 include Ariel 1, Biosatellites 1-3, the International Ultraviolet Explorer (IUE), SCATHA, the X-ray Timing Explorer (XTE), NEAR, and most recently, the Mars Global Surveyor and Mars Pathfinder.

<sup>117</sup> Ibid., I-3 - I-12.

<sup>118</sup> Ibid., I-36 - I-38.

<sup>119</sup> Ibid., I-15 - I-17. One OSO spacecraft, launched August 25, 1965 from Pad 17B, failed to orbit due to premature ignition of the Delta C's third stage engine.

<sup>120</sup> Ibid., I-13.

Ariel 1, developed jointly by the United States and the United Kingdom, was the first international satellite. Launched from Pad 17A on April 26, 1962, Ariel 1 performed ionospheric and solar radiation studies.<sup>121</sup> The IUE spacecraft was another international cooperative undertaking, this time between NASA, the British Science Council, and the European Space Agency. This orbiting observatory, launched from Pad 17A on January 26, 1978, provided astronomers with information on ultraviolet wavelengths that could not be measured from Earth. It also discovered a corona of hot gas surrounding the Milky Way galaxy.<sup>122</sup>

NASA launched its three Biosatellites between December of 1966 and July of 1969. The first two Biosatellites, carrying millions of animal and plant cells, tested the effects of weightlessness and space radiation on the growth of plants and animals. The third Biosatellite consisted of a re-entry section that carried an instrumented pigtail monkey into space and returned it to Earth.<sup>123</sup>

SCATHA, an acronym for Spacecraft Charging at High Altitudes, was the first spacecraft devoted primarily to studying the tendency of the near-Earth environment to create a build-up of static charges on geosynchronous orbiting satellites. A Delta 2914 launched the joint NASA-Air Force SCATHA spacecraft into orbit on January 30, 1979.<sup>124</sup>

Delta 2 vehicles launched NASA's XTE, NEAR, Mars Surveyor and Mars Pathfinder spacecraft. These missions were part of a new NASA effort to design and launch scientific spacecraft in a "better, faster, cheaper" fashion.<sup>125</sup> The XTE spacecraft, launched on December 30, 1995, was designed to study exotic space objects such as white dwarfs, neutron stars, binary star systems, black holes, and active galactic nuclei and quasars. The spacecraft NEAR (Near Earth Asteroid Rendezvous) will travel 3 1/2 years before reaching and studying the Eros and Mathilde asteroids. NASA launched NEAR on February 17, 1996. The Mars Surveyor and Mars Pathfinder spacecraft, launched respectively in November and December of 1996, are the first in a series of NASA Mars missions. The Mars Surveyor will orbit the planet, studying its atmosphere and climatic history. It will also map the entire surface of the planet. The even more ambitious Mars Pathfinder will send a roving probe down to the surface of Mars in an attempt to analyze the composition of the planet's rocks and soils.<sup>126</sup>

### Meteorological Satellites

Among the important meteorological satellite launches at Complex 17 are the TIROS and GOES (Geostationary Operational Environmental Satellites) series. The first generation TIROS series not only provided valuable weather data, they also helped revolutionize satellite weather

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<sup>121</sup> Ibid., I-24.

<sup>122</sup> Ibid., I-14.

<sup>123</sup> Ibid., I-32 - I-33.

<sup>124</sup> Ibid., I-23.

<sup>125</sup> "Encounter With EROS," *Aviation Week & Space Technology*, 12 February 1996, 46.

<sup>126</sup> "Upgraded Delta 2 Launches NASA's XTE," *Aviation Week & Space Technology*, 8 January 1996, 334; "Encounter With EROS," *Aviation Week & Space Technology*, 12 February 1996, 46; "Craft Is Launched To Explore Mars," *New York Times* (Late New York Edition), 8 November 1996, A1; "Back To Mars Via a New Path," *Aviation Week & Space Technology*, 22 April 1996, 56.

forecasting and weather satellite design. After the Thor-Able launch of TIROS at Pad 17A on April 1, 1960, NASA launched eleven additional TIROS missions with Delta boosters at Complex 17 through February of 1966.<sup>127</sup> NASA launched SMS (Synchronous Meteorological Satellite) 1 and 2 from Pad 17B on May 17, 1974 and February 6, 1975 respectively. These two satellites were prototype GOES satellites. SMS 1 provided continuous day and night images of the cloud cover over the United States and the Atlantic Ocean for the first time. SMS 2 tracked hurricanes, typhoons, and blizzards, providing instantaneous information on the location and course. NASA launched the first operational GOES satellite on October 16, 1975 at Pad 17B. Additional GOES launches occurred at Complex 17 in June of 1977 and 1978.<sup>128</sup>

### Communication Satellites

Complex 17 has been the launching site for a wide variety of communication satellites. Besides the early ECHO passive communications launches, the complex has supported launches in the Telstar, Relay, Syncom, Intelsat, Westar, Satcom, and NATO series.

Telstar I, launched on July 10, 1962, was the world's first active communications satellite. Owned, built, and operated by the AT&T Corporation, it was also the world's first commercial satellite. Telstar 2, placed in orbit on May 7, 1963, was a considerably larger version of Telstar 1. Both Telstar satellites transmitted in black and white and color in addition to handling dozens of transatlantic telephone conversations. These satellites used active-repeater techniques tested and perfected by the Army's Courier communications satellite, launched at Complex 17 on October 4, 1960.<sup>129</sup>

The Relay 1 and 2 and Syncom 1, 2, and 3 satellites also were early active-repeater communications satellites. The RCA-built Relay satellite, launched December 13, 1962, successfully transmitted television, voice, radio-photo and teletype in numerous public demonstrations. Relay 2, launched January 21, 1964, provided the first communications satellite link between Japan and the United States. Included among the coverage provided by the Relay satellites were President Kennedy's trip to Europe in 1963, the funeral of Pope John XXIII, and the election of Pope Paul VI.<sup>130</sup> The Syncom satellites, launched between February 1963 and August 1964, carried the first live telephone call between heads of government - President Kennedy in Washington, United Nations Secretary U Thant in New York, and Nigerian Prime Minister Balewa in his country. Only four months later, a Syncom satellite carried the proceedings of President Kennedy's funeral to Europe. Syncom 2 was the world's first satellite to achieve synchronous 24-hour orbit.<sup>131</sup>

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<sup>127</sup> A Summary of Major NASA Launches, II-1 - II-3. The last two TIROS satellites launched at Complex 17, on February 3 and February 28, 1966, were designated ESSA 1 and 2. The Environmental Science Services Administration funded these operational TIROS operational satellites (TOS).

<sup>128</sup> Ibid., II-16 - II-18.

<sup>129</sup> Twenty Years In Space: The Story of America's Spaceport, 174.

<sup>130</sup> Ibid.

<sup>131</sup> Ibid., 175; A Summary of Major NASA Launches, III-5.

The Intelsat (International Telecommunications Satellite Consortium) satellites were a series of communication satellites launched by NASA for the Communication Satellite Corporation (COMSAT) on a reimbursable basis. The communications satellite bill signed into law in August of 1962 created COMSAT. By international agreement among more than 80 nations, this corporation was charged with designing, operating, and maintaining the Intelsat global communications satellites. The first Intelsat launch at Complex 17, designated "Early Bird", occurred on April 6, 1965. Twelve more Intelsat launches at the complex followed, the last occurring on July 23, 1970.<sup>132</sup> The Intelsat satellites revolutionized television coverage by supplying live coverage of events to viewers worldwide.



**The first Westar launch, April 1974**  
(McDonnell Douglas photo)

The Westar and Satcom satellites were domestic commercial communications satellites. Owned and operated by Western Union, the Westar satellites relayed a mixture of various types of communications. Delta vehicles boosted three Westar satellites between April of 1974 and August of 1979. The Radio Corporation of America (RCA) financed three Satcom launches between December of 1975 and December of 1979. These satellites provided commercial communications capabilities to the 50 states. The launch of Satcom 1 on December 12, 1975 featured the first use of the Delta 3914 vehicle.<sup>133</sup>

NASA launched the first in a series of military communications satellites built for the North Atlantic Treaty Organization (NATO) on March 20, 1970. After the satellite reached geosynchronous orbit, NASA turned the satellite over to the Supreme Headquarters Allied Forces Europe. NASA has launched seven additional NATO communications satellites at Complex 17 through December of 1996.<sup>134</sup>

Besides domestic and military communications satellites, Complex 17 has also been the launch site for numerous national communications satellites. Included among these are Great Britain's Skynet series, Canada's Telesat series, France's and West Germany's Symphonie series, Indonesia's Palapa, Italy's Sirio, Germany's Kopernikus, India's Insat, and Korea's Koreasat.

<sup>132</sup> Twenty Years In Space: The Story of America's Spaceport, 175; A Summary of Major NASA Launches, II-12 - III-17.

<sup>133</sup> A Summary of Major NASA Launches, III-26 - III-27.

<sup>134</sup> Space and Missile Systems Organization: A Chronology, 1954-1979, 202; "Eastern Range Launches: Sites 17A and 17B."

### Navigation Satellites

The first navigation satellites launched at Complex 17 were the Navy's Transit satellites. A Thor-Able vehicle failed to place the Transit 1A satellite into orbit on September 15, 1959. However, Thor-Able-Star vehicles subsequently boosted six Transit satellites for the Navy from Pad 17B. The Navy used these satellites to provide their Polaris missile submarines with highly accurate navigational data. The satellites also provided navigational assistance to ships and airplanes in all weather conditions.<sup>135</sup>

In 1978, the Department of Defense launched four prototype NAVSTAR Global Positioning System (GPS) satellites from Vandenberg Air Force Base. After successful tests with the satellites were completed, the Department of Defense authorized full-scale development of the GPS in August of 1979. The Air Force launched a total of eleven NAVSTAR GPS satellites from Vandenberg Air Force Base by mid-October of 1985.<sup>136</sup>

The Department of Defense subsequently developed an improved second generation version of the NAVSTAR GPS satellite. By Congressional directive, a 21-satellite fleet of these improved satellites were to have been launched by the Space Shuttle.<sup>137</sup> However, after the disastrous Challenger disaster of 1985 and the shuttle launch delays that followed, the Air Force decided to shift the NAVSTAR GPS payloads from the Space Shuttle to expendable launch vehicles. This would allow the new system to become operational at a much sooner date. The Air Force held a competition among aerospace companies for a "Medium Launch Vehicle" to launch the satellites. McDonnell Douglas won the competition with its proposal to use the Delta II. One of the key factors in the Air Force's selection of the Delta II was the ability of the Delta vehicle to attract commercial launch business. The Air Force awarded McDonnell Douglas the NAVSTAR contract in January of 1987.<sup>138</sup>



NAVSTAR GPS satellite

Modifications to Complex 17 were necessary to accommodate the larger Delta II vehicle. McDonnell Douglas initiated the work soon after winning the NAVSTAR contract. While the modifications were underway, the Air Force regained administrative control of Complex 17 from NASA via a Memorandum of Understanding (signed August 16, 1988). The Air Force was responsible for ensuring that safety and environmental standards were met for commercial and

<sup>135</sup> Twenty Years In Space: The Story of America's Spaceport, 178.

<sup>136</sup> Vandenberg AFB Launch Summary (Vandenberg Air Force Base, California: Headquarters, Strategic Missile Center, January 1991). The Air Force conducted the Vandenberg AFB NAVSTAR GPS satellite launches at Space Launch Complex 3 using Atlas F boosters.

<sup>137</sup> The number of NAVSTAR GPS satellites was later increased to 24.

<sup>138</sup> Information supplied by Mark Cleary, Historian, 45th Space Wing, Patrick Air Force Base, Florida.

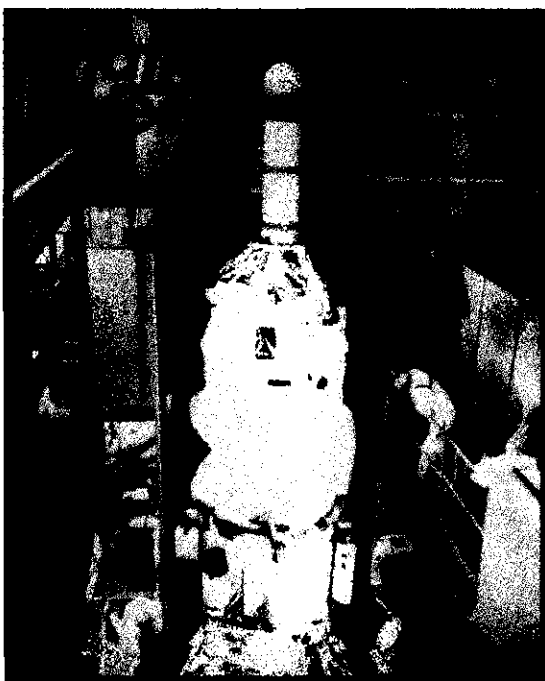
Department of Defense Delta II launches while McDonnell Douglas was responsible for producing, marketing, and launching the Delta II.

After completing the modifications at Pad 17A in mid-May of 1988, McDonnell Douglas conducted the first Delta II launch at the pad on February 14, 1989. The payload was a NAVSTAR II GPS satellite, the first to be launched from the Eastern Range. By the end of 1996, McDonnell Douglas had launched a total of 22 NAVSTAR II GPS satellites at Pad 17A. Meanwhile, modifications to Pad 17B were completed in late 1989. The first Delta II launch at the pad took place on February 14, 1990. The payloads were LOSAT L and R, two Strategic Defense Initiative Organization experimental satellites. Through 1996, McDonnell Douglas had conducted a total of 24 Delta II launches at Pad 17B. The payloads for these launches included commercial satellites, NASA scientific payloads, and five NAVSTAR II GPS satellites.

### Special Strategic Defense Initiative Launches at Complex 17

In the late 1980s and early 1990s, Complex 17 supported several special Strategic Defense Initiative (SDI) research and development missions. President Ronald Reagan first called for the development of a space-based missile defense system in the early 1980s. He envisioned an operational SDI system reducing or even eliminating the threat of a nuclear attack on the United States by the Soviet Union.<sup>139</sup>

The Strategic Defense Initiative Organization (SDIO), created in 1984 by the Department of Defense, was responsible for pursuing research and development of the SDI.



First SDI mission at Complex 17 makes cover of *Aviation Week & Space Technology*

The first SDI mission at Complex 17 took place on September 15, 1986 when a Delta 3920 vehicle boosted an SDI experimental satellite. After deploying from the Delta's second stage, the satellite maneuvered to intercept and destroy the stage. The highly successful experiment provided important data for the design of small kinetic energy weapons that could destroy Soviet ballistic missiles.<sup>140</sup>

The second SDI launch at Complex 17 took place on February 8, 1988 when a Delta 3910 vehicle boosted a \$250 million, 6,000 pound-satellite. The primary purpose of this satellite was to determine whether energy radiating from warheads after their release in space could be detected at different wavelengths and against a variety of backgrounds. The satellite ejected 14 different objects, ten of which were believed to have been simulations of nuclear

<sup>139</sup> SDI eventually was commonly referred to as "Star Wars".

<sup>140</sup> "SDI Delta Space Experiment To Aid Kill-Vehicle Design," *Aviation Week & Space Technology*, 15 September 1986, 18.

warheads and decoys. This test verified some of the design elements of the sensors that were being designed for the SDI.<sup>141</sup>

Another SDI experimental mission, designated Delta-Star, was boosted into orbit for the SDIO by McDonnell Douglas's last Delta 3920 vehicle. The launch took place at Pad 17B on March 24, 1989. The Delta Star sensor spacecraft was designed to generate rocket and missile plume data by observing launches over a six month span. The data collected by Delta Star was to be used by scientists to design space defense targeting and tracking systems.<sup>142</sup>

Delta vehicles launched three other experimental SDI satellites in the early 1990s. The first Delta II vehicle to be launched at Pad 17B boosted two of these satellites on February 14, 1990. The satellites were Losat-L and Losat-R. The Losat-L satellite acted as a target for lasers while the Losat-R satellite was a relay mirror experiment aimed at helping scientists prove that a space-based mirror could capture and relay an uplinked ground-fired laser beam.<sup>143</sup> The classified Losat-X satellite, launched by a Delta II on July 7, 1991 (along with a NAVSTAR II GPS satellite), was the last SDI mission at Complex 17.<sup>144</sup>

### **Delta Launch Process**

The overall process that culminates with a Delta launch at Complex 17 begins at McDonnell Douglas's plant in Huntington Beach, California. Except for the Morton Thiokol solid rocket motors, the Rocketdyne main engine, the Aerojet second stage engine, and various upper stage components, the Huntington Beach plant is where the basic components of the Delta vehicles are built. After the various new components are tested, McDonnell Douglas sends them to their plant in Pueblo, Colorado for "final" assembly with other components. From Pueblo, McDonnell Douglas transports the completed stages by truck to Hangar M in the Industrial Area at Cape Canaveral. The components receive an inspection at Hangar M and are then stored there until needed for a launch.

Roughly three months before an anticipated launch date, technicians begin testing the stages and various vehicle systems at Hangar M. After these tests are completed, the first stage of the Delta vehicle is transported to the Horizontal Processing Facility (HPF) where technicians install the destruct system and prepare the stage for erection at the launch pad. Meanwhile, the second stage of the Delta is transported to Area 55 (located east of Complex 17 on Lighthouse Road) where it is pressurized, checked for leaks, and then prepared for erection at the launch pad. When activities at the HPF and Area 55 are completed, the stages are transported by trailers to a pad at Complex 17.

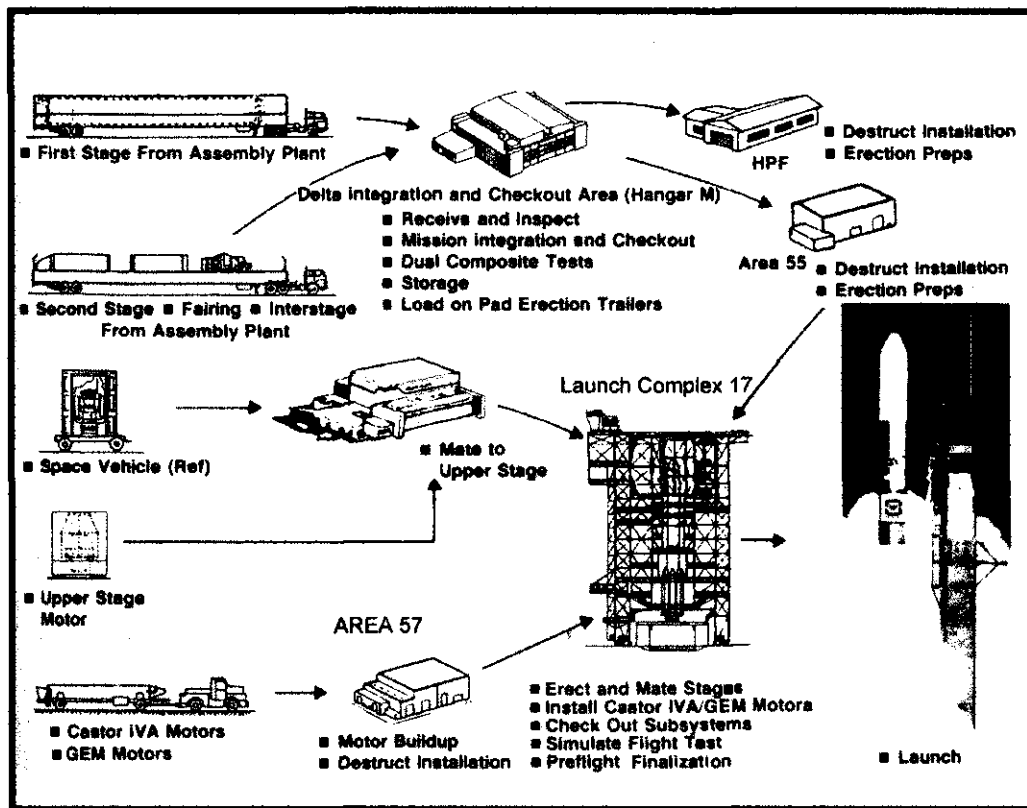
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<sup>141</sup> "SDI Test Takes Measure of Potential Targets," *Science*, 19 February 1988, 860; "Delta 181 Shows Discrimination of Warheads Easier Than Predicted," *Aviation Week & Space Technology*, 7 March 1988, 22.

<sup>142</sup> "SDIO Begins Measuring Booster Plumes With Delta Star Sensors," *Aviation Week & Space Technology*, 3 April 1989, 26.

<sup>143</sup> "SDI Experiments Set for Launch in January," *Aviation Week & Space Technology*, 11 September 1989, 35.

<sup>144</sup> "Eastern Range Launches: Sites 17A and 17B."



Delta Launch Site Operations Flow at CCAS

The Delta's solid rocket motors are initially transported to Area 57 (located north of Complex 17 along Flight Control Road) where they are inspected, checked for leaks and flaws, and then built up with destruct harnesses and nose cones. After this is completed, the motors are transported to Complex 17 for integration. The Delta's upper-stage motor arrives at the Ordnance Storage Area (located north of Lighthouse Road along Cape Road) and is inspected before being placed in a cold chamber. The stage is then x-rayed for flaws, placed in a shipping container and transported to a processing facility (such as the NAVSTAR Processing Facility along Flight Control Road) for installation of the Payload Attach Fitting. After being spin balanced at NASA's Explosive Safe Area 60 (located north of the Industrial Area), the upper-stage is returned to the processing facility where it is mated to its payload. Both are then transported to Complex 17.

At Complex 17, the various stages are erected and mated on the pad and the solid rocket motors are installed. When these activities are completed, technicians conduct subsystems checkouts and perform numerous preflight tests before the vehicle is finally launched.

## Architectural Description of Complex 17

Launch Complex 17 is located at the eastern end of Lighthouse Road between Complex 18 to the north and Complex 26 to the south. The complex has two nearly identical launch pads sharing a single blockhouse. The primary facilities located at the complex are the single blockhouse, the two launcher buildings and the two mobile service structures (MSS.) Secondary facilities consist of the Ready Room/Machine Shop, the fuel and oxidizer farms, an air conditioning facility, the theodolite building and the Digital Image Generation System (DIGS) buildings. Both pads and their support facilities are enclosed within a chainlink security fence, 10' in height. Several support facilities are located outside this perimeter fence. (Figure 1)

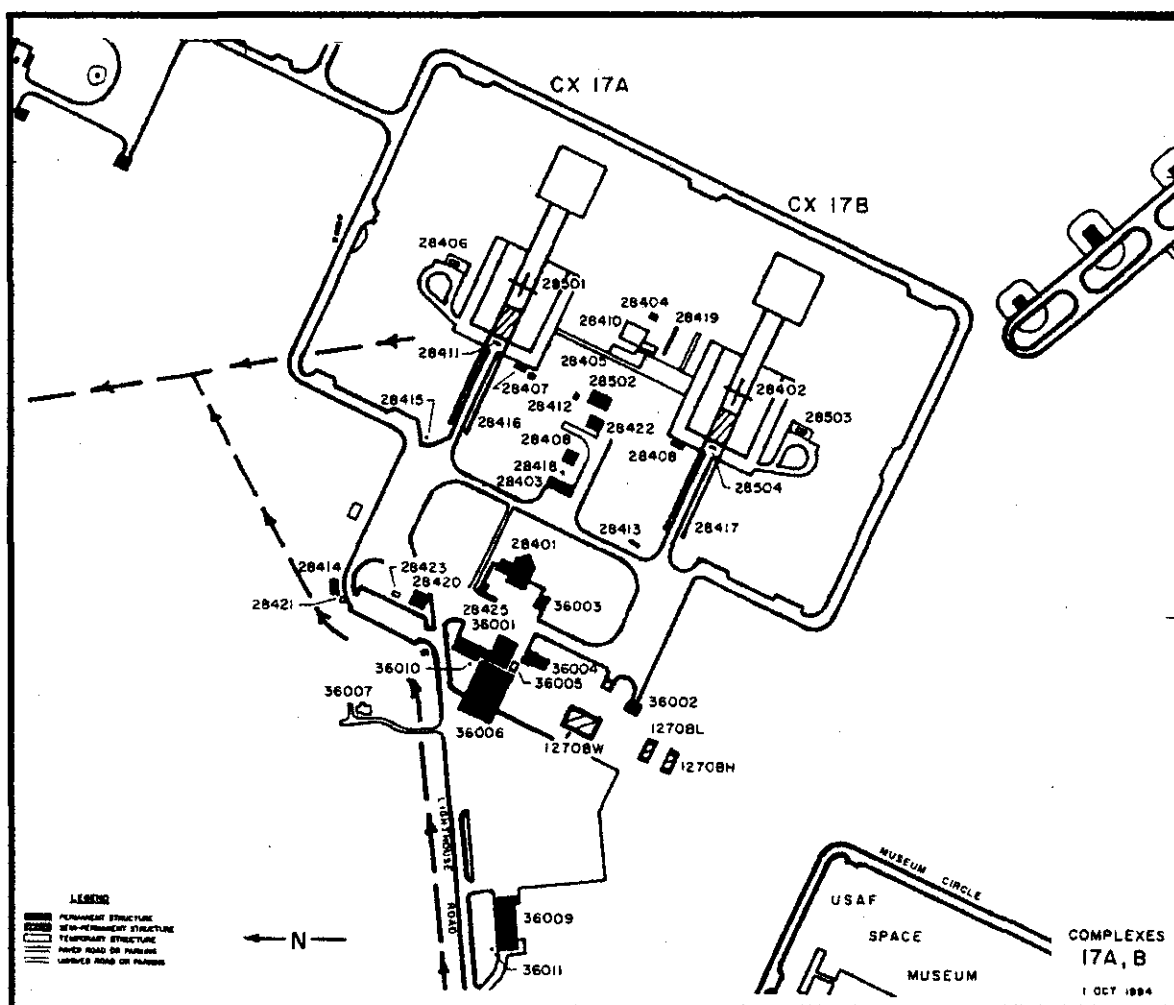


Figure 1: Map of Complex 17

Source: Basic Information Guide, Cape Canaveral, Facilities, Utilities, Instrumentation, Communications, Engineering and Environmental Planning Facilities Planning, Johnson Controls World Services, 1994.

**Launch Pads A and B and Associated Facilities****Facility 28401: Blockhouse<sup>1</sup>** (HAER No. FL-8-5-A)

The Blockhouse, constructed in 1958, is a one and one-half story building encompassing 4,262 square feet. The building is used as the operations and communications control center for all launches at the complex. The building is T-shaped with a triangular projection on the southeast side. The dimensions of the building are 88'-9" long by 43'- 6" wide. The main portion of the blockhouse measures 18'-10" to the top of the slightly curved roof. A smaller one-story rectangular non-hardened portion of the building is located on the northwest side (or rear) of the building. This section is 43' wide, 18' long and 9'-2" in height. A hardened wing was added to the building's north side in 1968. This blastproof addition measures 28' by 28' and is constructed of reinforced concrete and houses the telemetry ground station room. (See photo FL-8-5-A-1 through FL-8-5-A-4)

The blockhouse is of "hardened" construction and considered to be blastproof. Construction consisted of poured reinforced concrete designed to withstand a blast equivalent to 15,000 pounds of TNT exploded at a distance of 300' from the blockhouse. Equivalent static pressures of a side blast equals 1,390 pounds per square foot and, a face-on blast equals 3,140 pounds per square foot. The walls range in thickness from 8" in the smaller section to 2' in the building's main section. The floor is constructed with a reinforced concrete foundation, 2' thick, topped with 8" of compacted sand and an additional 6" of reinforced concrete. The domed roof ranges in thickness from 5'-6" to 8' at its apex. The roof is constructed of multiple layers of reinforcing steel embedded in high strength concrete. The building's projections were further protected in 1964 by a roof-height revetment of compacted earth extending out 30' towards the launch pads. In 1989, further protection of the blockhouse was required. At this time, additional compacted earth was added to the south side of the blockhouse and to all sides of the north wing. Heavy reinforcement of the blockhouse was required for two reasons. First, the thick walls and roof must protect technicians, instrumentation, and sensitive equipment from the launch blast, and toxic gases. Second, the building must withstand the shock of a misfired or exploding missile.

Located at the "junction" of the main building and the triangular projection are two concrete cooling/vent towers that terminate at the building's roof line. The rectangular towers are capped with an angled aluminum hood vent. (See photo FL-8-5-A-5 through FL-8-5-A-7)

Access into the blockhouse is possible from the west side through a 6' by 7' doorway set within the wall dividing the hardened and the non-hardened portions of the building. The single panel blastproof door is constructed of 1/4" steel plate. The semi-hardened tunnel, covered with a earth revetment, terminates in the non-hardened rear portion of the blockhouse.

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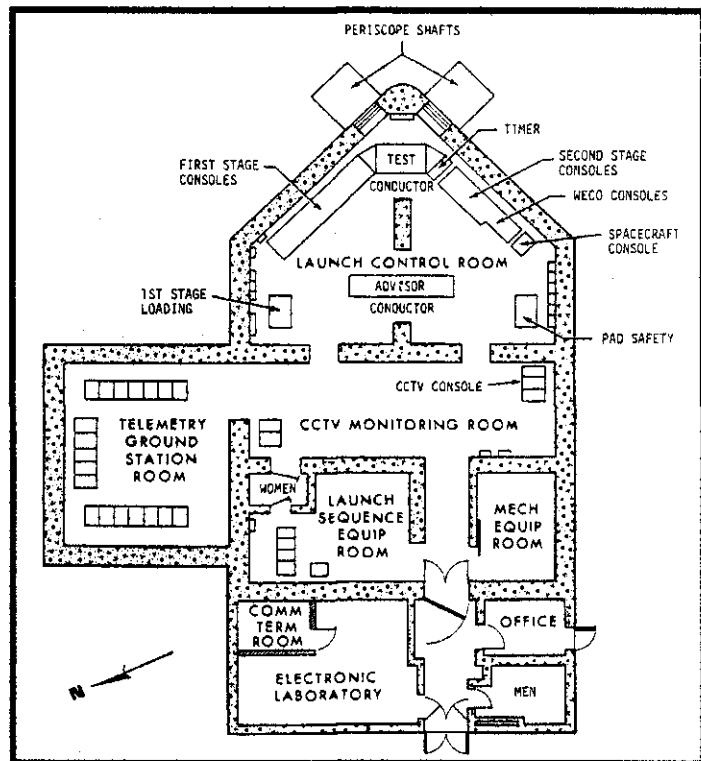
<sup>1</sup> The majority of this information was obtained from architectural drawings Launching Facility - Blockhouse, Steward and Skinner and Marice H. Connell and Associates, Inc., Miami, Florida, March 1954; 1964.

The interior of the building was divided into the launch control room, closed caption television (CCTV) monitoring room, launch sequence equipment room, mechanical equipment room and latrine. The non-hardened rear section contained the electronic laboratory, communication terminal room, office and an additional latrine. The building's north wing contains the telemetry ground station room equipped with a computer cable access floor 14" deep. This access space is connected to the cable trays interlaced throughout the blockhouse. (Figure 2) (See photo FL-8-5-A-8)

The concrete cable trays, measuring 10" wide by 12" deep, are embedded within the concrete slab around the perimeter of the launch control room, the CCTV monitoring room, and the launch sequence equipment room. The trays are covered with removable steel plates and allow for direct connection with the control consoles. The trays terminate in the "nose" of the firing room in a recessed terminal box, 3' long and accessed by a 3/8" steel plate door.

The launch control room, located in the point of the blockhouse, is further divided into two firing "rooms" (one for each launch pad) and partially divided by a concrete wall, measuring 19'-6" long by 10'-4" high. The projecting configuration of the firing rooms provides the system engineers and technicians with the greatest degree of visibility of the launch pads. (See photo FL-8-5-A-9 through FL-8-5-A-11)

The configuration of the firing room allows for safe optimum viewing and control of each launch pad. Each firing room is equipped with a complete array of communication and support equipment for its respective pad. For clear and safe visibility of the pads each firing room contained two blast-proof observation ports set within the angled walls. Two of the four observation ports measured 8'-6" long while the smaller two ports measured 4'-6" in length. Each port consists of two stacked "viewing windows." The lower window is located 4'-9" above the finished floor and measured 1'-8" in height. The upper window is angled at 30 degrees from horizontal and also measured 1'-8" in height. The steel-frame windows, set into the reinforced concrete walls, are constructed of four sheets of shock-resistant armor glass, 4" thick, separated by neoprene gaskets.



**Figure 2: Floor Plan - LC 17 Blockhouse**

Source: Handbook of ULO Facilities at the Eastern Test Range

In 1964, measures were taken to enhance the protective nature of the blockhouse. Tons of earth were banked around the perimeter of the building and extended 30' towards the launch pads. The banked earth covered the original observation ports in the firing rooms. Consequently, two periscope ducts were installed in the window wells of the smaller two observation ports. A concrete duct extended up the front of the building terminating at the roof line. Mirrors were then placed at the top of the duct to allow viewing of the launch pad from the firing room.

Today, the blockhouse is completely surrounded by an earthen berm, leaving only one-third of the building exposed. The west side of the blockhouse also contains a rough-faced concrete masonry unit retaining wall. The reinforced access tunnel is located at the building's southwest corner.

The building also contains a steel observation deck accessed from the building's southwest side. One steel ladder extends up the southwest side of the annex and provides access to the annex roof. A second steel ladders provides access to the roof of the blockhouse and observation platform. The platform is 37' long with a deck area measuring 6' by 8'. A metal pipe railing, 3' in height and 1 1/2" thick, extends around the perimeter of the platform and deck area.

#### **Instrumentation Trench**

Each firing room contains a concrete instrumentation trench extending out to its respective launch pad, and terminating in the launcher building's electronic equipment room. The U-shaped instrumentation trenches are recessed approximately 4' below grade and are covered with either aluminum plates or checkered steel plates.

The recessed instrumentation trenches are constructed with reinforced concrete walls, 8" thick, and are 2'-3" deep by 3'-6" wide (inside dimensions.) The trench extends approximately 3" above grade. The trenches are covered by removable aluminum plates. The walls of the trenches are lined with four adjustable 8" wide steel brackets used to support the hundreds of yards of communication and electrical cabling. The trenches extend from the blockhouse to the edge of the concrete launch pad apron.

At the point where the trenches cross the complex road, the aluminum cover plates are replaced by 3/4" steel plates, 2' wide. The plates rest flush with grade and are supported by steel beams. The trenches measures 2'-6" deep (to top of plate) by 3'-6" wide with reinforced concrete walls and floor, 8" thick. All cover plates are weatherproofed with neoprene seals.

The configuration of the instrumentation trenches changes once again when the trench reaches the launch pad. At this point the trenches become 7'-6" deep by 5' wide with reinforced concrete walls, floor and "roof." The roof is located slightly below grade and covered with 6" of compacted sand and bituminous material.

## Launch Area

Located 550' southeast of the blockhouse is the launch area. The area contains two nearly identical launch pads (17A and 17B), umbilical towers, mobile service structure (MSS), flumes, retention ponds, and fuel tanks farms. Auxiliary facilities include the air conditioning building, alignment buildings, electrical distribution buildings, and storage buildings.

## Launch Pad A (Figure 3)

### Facility 28501: Launch Pad A<sup>2</sup> (HAER No. FL-8-5-B)

#### Launcher Building

The launcher buildings for both pads are virtually identical to each other and located approximately 550' apart. Each reinforced concrete and steel building is constructed to withstand any potential explosion resulting from the highly flammable and propellant-contaminated atmosphere produced during a launch. The two story rectangular building, constructed in 1959, measures 50' by 59' by 28' in height, and has 1' thick walls. A cantilevered steel launch deck and flame deflector is located on the building's eastern side. (Figure 4) (See photo FL-8-5-B-1 and 10)

The launcher building provides a protective shelter for shops, instrumentation, service and transfer equipment, and electrical switching gear. The building is equipped with two rooms, the electronic equipment room and the flame deflector valve room. Both rooms measure approximately 16' wide by 25' long. The electronic equipment room houses the electronic equipment used to interface with the launch vehicle. The instrumentation cables, entering into this room from the instrumentation trench, are distributed to electronic equipment within the launcher building or up through the building to the launch deck, umbilical tower and MSS.

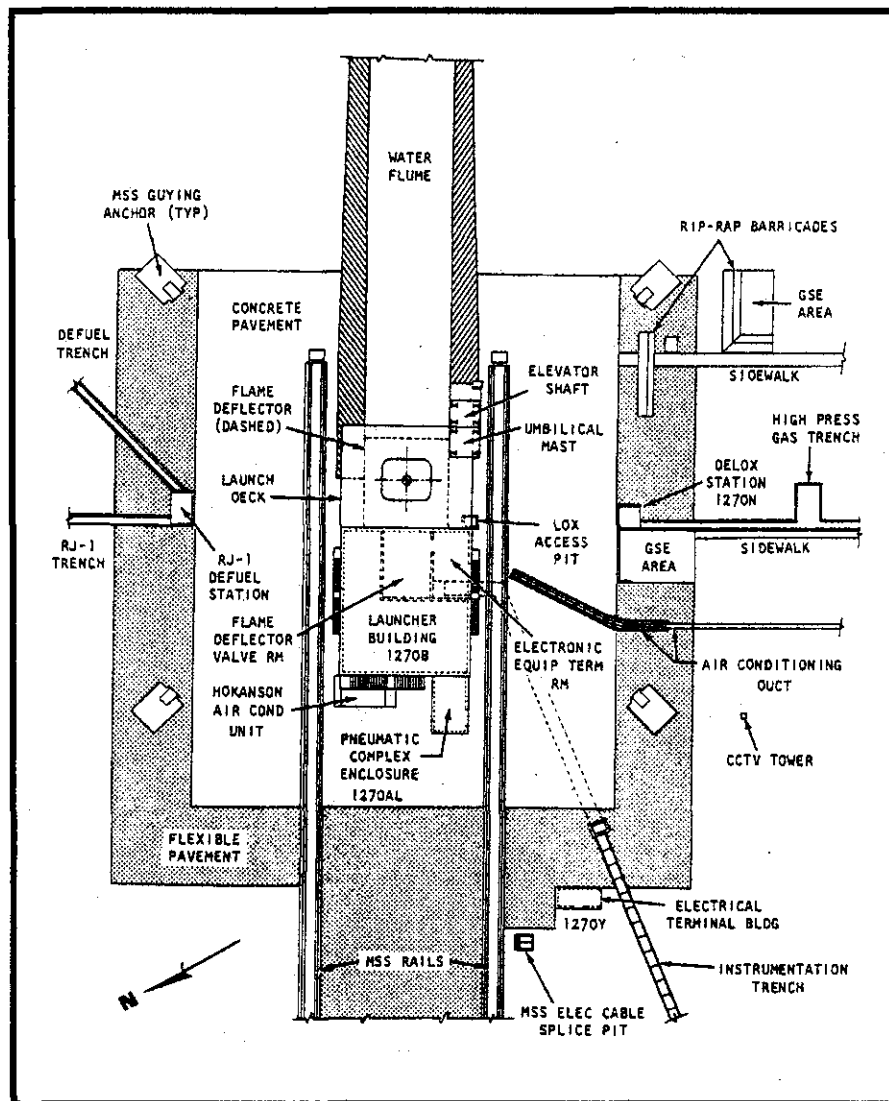
The flame deflector valve room controls the deluge water used for sound and flame suppression during a launch. Both rooms are accessible via doors located at ground level. The remaining unused half of the building (the western portion) is completely filled with sand.

The pneumatic complex enclosure and air conditioning unit area are located in two smaller additions on the launcher building's west side. The pneumatic complex, facility 28411, was constructed in 1968. (See photo FL-8-5-B-12 through FL-8-5-B-17) The one-story concrete block addition encompasses 318 square feet and contains a hydraulic cart (also known as a mule) for the booster hydraulics non-flight systems. At liftoff the cart is disengaged and the missile's pneumatic system takes over controlling its internal hydraulic system.<sup>3</sup> The air conditioning unit is also one-story in height, rectangular in plan and constructed of concrete block. The air conditioning unit supplies conditioned air to the trans-stage and spacecraft shroud.

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<sup>2</sup> The majority of the information within this section came from the Handbook of ULO Facilities at the Eastern Test Range, (Facilities Liaison Office, Unmanned Launch Operations, John F. Kennedy Space Center, NASA, Kennedy Space Center, Florida, May 1969).

<sup>3</sup> Mr. Albert Grundman, McDonnell Douglas Engineer, interview by authors, Tape recording, Cape Canaveral Air Station, Florida, 13 November 1996.



**Figure 3: Site Plan - Pad A**

Source: Handbook of ULO Facilities at the Eastern Test Range.

The launch deck area consists of the cantilevered steel launch deck, steel flame deflector and free-standing fixed umbilical mast. Access to the launch deck area or "roof" of the building is possible via three external steel staircases or from the MSS when it is in the service position. The launch deck, level with the roof of the launcher building, is 50' wide and extends beyond the launcher building by 38'. The launch deck is constructed of high strength steel girders and beams covered with 1/2" thick steel plates.

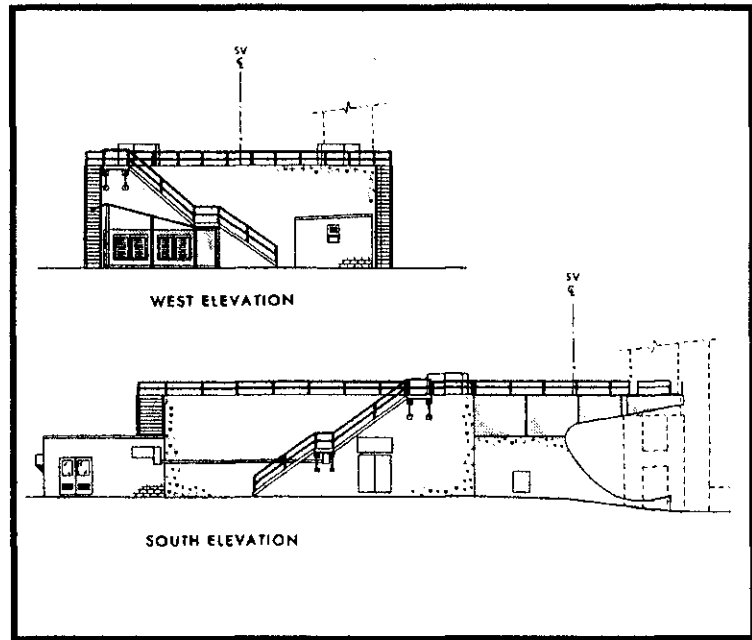
### Captive Test Stand

While the launch pads are used for preparing the rocket, the rocket itself rests on a steel captive test stand. The test stand is located at the center point of the cantilevered launch deck. The steel multi-arm structure holds the launch vehicle in an upright position during build-up, check-out and launch sequencing. (See photo FL-8-5-B-2 through FL-8-5-B-4)

The steel captive test stand has been modified several times to accommodate the increased size and weight of the Delta rocket. During the early 1960s, the captive test stand was a low steel ring with several arms. By 1966, the captive test stand was a simple steel structure with four arms. Today, the current generation captive test stand consists of six legs, five permanent and one and three pins. Located on the west side of the captive test stand is the retraction system for leg 4. When the missile lifts off, the arm must clear the rocket's nozzle extension and turbine exhaust stand. When the booster begins to lift from the stand a pin is pulled out and the leg retracts and is held in place so as not to interfere with the nozzles on the solid motor during liftoff.<sup>4</sup>

The deck plates surrounding the captive test stand are labeled with an "N," "S" and "E" for north, south and east respectively. When in place, these three plates allow pad support crew to access the rocket during build-up. Before launching the rocket, the plates are retracted, exposing the flame deflector below and allowing the exhaust flames to be directed down and away from the launch vehicle.

The cantilevered steel girders supporting the deck plates range in thickness from 2' at the eastern cantilevered end to 8'-11" at the launcher building connection point. A number of lines extend up and through the cantilevered deck supplying various components within the mobile service structure and umbilical mast. These include a 1" helium line, a 3/4" helium line, a 6" LOX line, a 1" air line, and a 3" demineralized water line.<sup>5</sup>



**Figure 4: Launcher Building - Pad A**

Source: Handbook of ULO Facilities at the Eastern Test Range.

<sup>4</sup> Ibid.

<sup>5</sup> Captive Test Stands 17A and 17B Steel Deck Framing Engineering Drawings, Aerojet-General Corporation, Azusa, CA, 1956.

In 1968, to accommodate the new long-tank Delta space vehicle, the launch deck, the umbilical tower and mobile service tower were modified. The original 1/4" metal decking was completely replaced with 1-1/2" steel.<sup>6</sup>

### **Flame Deflector**

The flame deflector is located directly below the launch mount. During a missile launch, the launch blast is directed down to the concrete and steel flame bucket which then sends the blast eastward. A water deluge system, located throughout the launch deck area and the flame deflector, is used to cool and protect the launch equipment from the extreme heat and corrosive environment generated by the launch blast. Several water stanchions, located on the launch deck, focus their spray towards the launch mount. Below the launch deck, the flame deflector is equipped with numerous pipes, sprayers and nozzles. The main supply header supplies six sleeves (ranging in size from 10" to 16" in diameter) with water which then branch to 4" pipe sleeves and 2 1/2" pipe nozzles covering the entire deflector face.<sup>7</sup> A drain point captures the water from all areas of the pad and directs it towards the retention pond. The drain point is also used as a collection tool in the case of a fuel spill. (See photo FL-8-5-B-5 and FL-8-5-B-6)

The flame deflector itself is 33' wide and parabolically shaped directing the exhaust to east. It is constructed of 1-1/4" steel backed with concrete and supported with steel girders.

### **Retention Pond**

The retention pond measures 60' wide by 130' long and is lined with concrete. Located on east side of the complex, the concrete retention pond is connected to the launch pad area by means of a 230' long concrete basin and flume. During launch, the flume channels carry the deluge water from the launch deck to the retention pond. After every launch, the deluge water in the basin was tested for fuel contamination and neutralized if necessary, or hauled away as toxic waste. A new impermeable pond liner was installed in the retention pond in 1993. (See photo FL-8-5-B-11)

### **Umbilical Mast**

The umbilical mast (UM) is a structural steel tower located in the southeast corner of the launch deck. The function of the UM is as a service provider and retractable booms supply electrical power, instrumentation, propellants, pneumatics and conditioned air to the launch vehicle or payload.<sup>8</sup> (Figure 5) (See photo FL-8-5-B-7 through FL-8-5-B-9)

Originally, the UM was a simple retractable steel structure located in the southeast corner of the launch deck. Two large retractable umbilical cords and several smaller cords provided the various connections required to support the missile. However, due to the continuous development of the Delta and Thor rockets a new umbilical mast was constructed in 1969. The new UM was a fixed-in-place open steel-framed structure, 133' tall. In conjunction with the numerous missile connections, the new UM also contained 15 platforms and work levels, ladders

<sup>6</sup> "New Mission Coming: Pad 17A Readied For Longer Delta," Spaceport News, 15 February 1968.

<sup>7</sup> Captive Test Stands 17A and 17B Flame Deflector Piping Engineering Drawings, Aerojet-General Corporation, Azusa, CA, 1956.

<sup>8</sup> J. L. Nayler, A Dictionary of Astronautics (New York: Hart Publishing Company, Inc., 1964), 299.

and an elevator. The new UM also contained two two-level retractable steel walkways at the ninth and twelfth levels to provide emergency access capability to the trans-stage sections and the spacecraft shroud.<sup>9</sup> When not in use, the pneumatically-controlled retractable walkways are stowed against the UM's west face.<sup>10</sup>

The bottom three levels of the UM (beginning at launch deck height) were enclosed with steel plate coverings to protect it against the missile blast. A new foundation of replaced the original steel foundation for the UM. Additional modifications were necessary on the launch deck and apron to accommodate the numerous connections required to support the missile.<sup>11</sup>

The numerous launch vehicle connections are possible through the main cabletray on the UM's north side. Two cooling air ducts extend up the UM's south face along with the  $\text{GN}_2$  and  $\text{GH}_e$  lines. All communication wiring is contained within the conduit which is purged with  $\text{GN}_2$ .

In 1968, the umbilical tower was raised 14'-6" to accommodate the new long-tank Delta rocket. This was accomplished by removing the upper portion of the original tower and inserting a new, higher section back in place. Additional changes included reinforcing the steel framing to accommodate the additional weight and height and modifying and relocating the work platforms to accommodate the shape of the new launch vehicle.<sup>12</sup> Today,

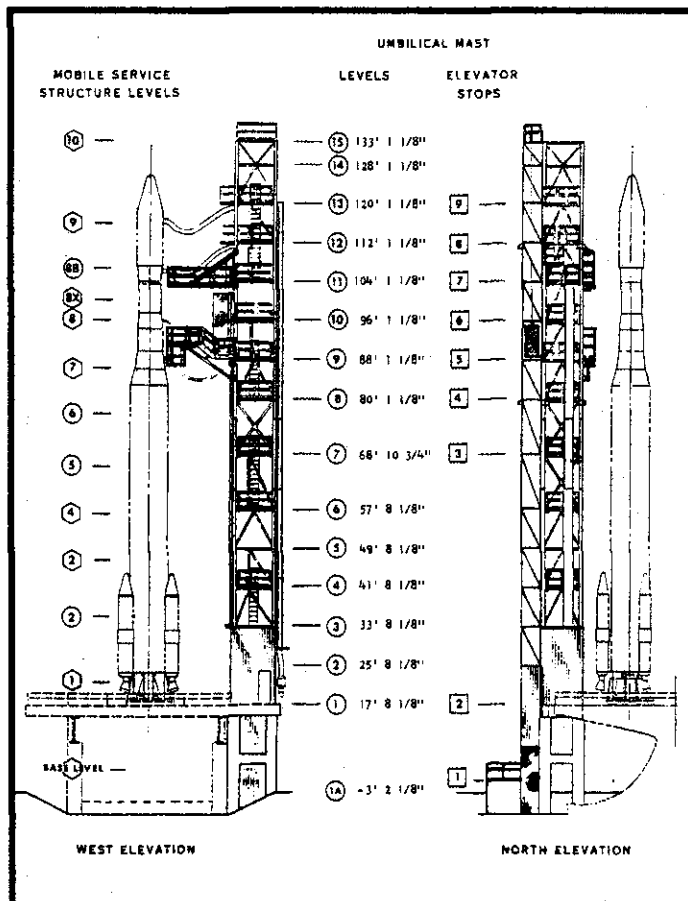


Figure 5: Umbilical Mast - Pad A

Source: Handbook of ULO Facilities at the Eastern Test Range.

<sup>9</sup> Handbook of ULO Facilities at the Eastern Test Range, 6.36.

<sup>10</sup> Ibid., 6.38.

<sup>11</sup> "SM-46383 Fixed Umbilical Mast," Missile & Space Systems Division, Douglas Aircraft Company, Inc., Santa Monica, CA, January 1965, Architectural Descriptions and Drawings, Phase 1.

<sup>12</sup> "Launch Unit Growing at Kennedy," Orlando Sentinel, 15 September 1968.

the shrouded UM contains an electrical umbilical, a propulsion umbilical, and a digzair umbilical. The digzair umbilical was used to provide airflow to the guidance section.<sup>13</sup>

**Facility 28416: Pad A Mobile Service Structure (HAER No. FL-8-5-C)**

The mobile service structure (MSS) stands 133' tall, weighs approximately 500,000 pounds, and is predominantly rectangular in shape. The structure is constructed of open steel-framing with nine retractable servicing and checkout levels for vehicle preparation, checkout, simulated flight and sequence testing, and countdown preparation.<sup>14</sup> (Figures 6 and 7) (See photo FL-8-5-C-1 through FL-8-5-C-5, FL-8-5-C-9, and FL-8-5-C-17)

The MSS, mounted on drive truck assemblies, is used only during the build-up and servicing of the launch vehicle. The four truck assemblies are mounted on steel rails set 58' apart. Each of the drive truck assemblies measures 49" in height, between 70" and 98" in width, 100" in length, and weighs 25,820 pounds. They can travel at speeds between 0-50 feet per minute<sup>15</sup> (See photo FL-8-5-B-6 and FL-8-5-B-8)

Shortly before launch the MSS is moved to its stowed position, approximately 400' to the northwest, and "locked down" using four concrete guying anchors and pins. Four additional guying anchors are located an equal distance from the launch deck for locking the MSS in place during servicing.

Unlike other mobile service structures used at other CCAS launch complexes, this MSS moves to and from the launch deck from the western side of the complex. The MSS moves completely over the launcher building and straddles the launch deck when it is in the service position. The eastern face of the MSS opens and envelopes the missile and launch mount. Once enclosed, the platforms are lowered and the white room door closes to protect and avoid damage to the highly sensitive electronic equipment on the space vehicle. The majority of the mobile service structures used at CCAS moved to and from the launch deck from an easterly direction. The MSS would travel to the launch deck from the direction of the retention pond. When in the service position, the MSS would straddle the flume and flame bucket. (See photo FL-8-5-B-10 through FL-8-5-B-16)

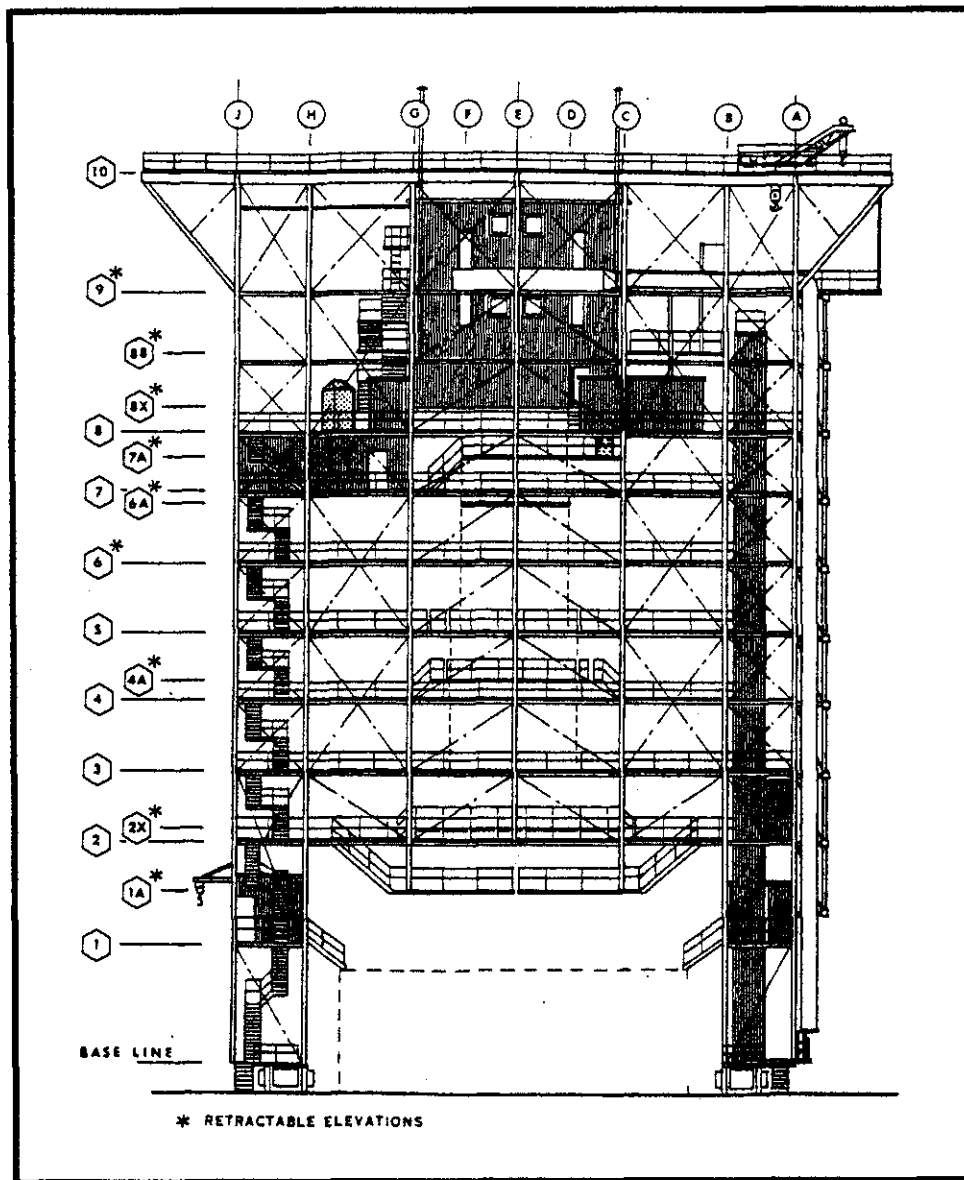
The primary functions of the MSS are to erect and mate the first stage booster to the launch mount as well as the build up and mating of the second stage, third stage, and payload. Originally, a 10-ton hoist and 3-ton jib hoist were mounted on a bridge atop the MSS. The two hoists are used to lift heavy equipment and to maneuver the different stages into place. A one

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<sup>13</sup> Mr. Albert Grundman, McDonnell Douglas Engineer, interview by authors, Tape recording, Cape Canaveral Air Station, Florida, 13 November 1996.

<sup>14</sup> International Reference Guide to Space Launch Systems, 212.

<sup>15</sup> Technical Manual: NASA/DELTA d17.15.31.0, Operations and Maintenance, MST Propulsion Drive System, John F. Kennedy Space Center, September 1970, Section 1.

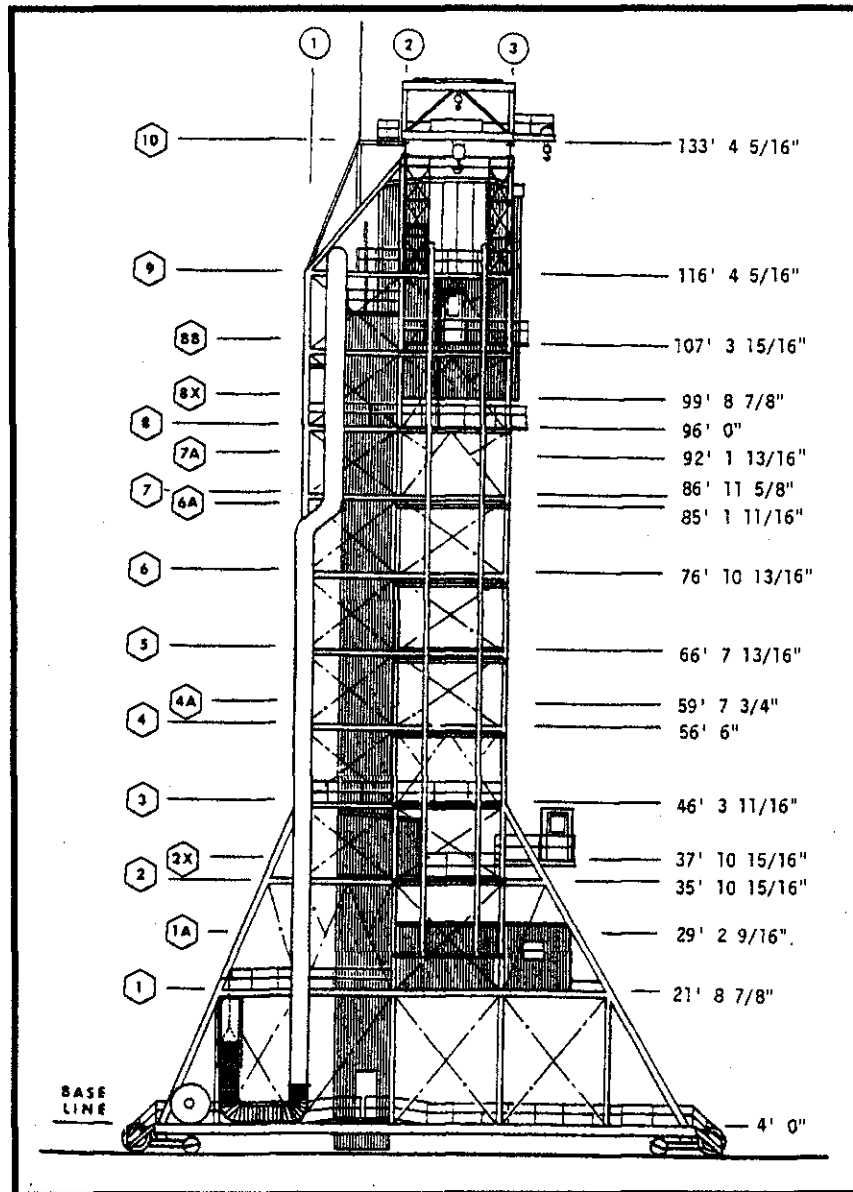


**Figure 6: East Elevation - Pad A Mobile Service Structure**

Source: Handbook of ULO Facilities at the Eastern Test Range.

and one half ton monorail hoist was located on Level 1 for lifting equipment to the launcher deck.

The cranes have been reinforced, upgraded, and expanded over the years to accommodate larger and heavier vehicles. The nine levels of the MSS are equipped with numerous work platforms. Access to the different levels is possible by either a one ton capacity elevator, stairs from the launcher deck or from the umbilical mast via two crossovers at Levels four and eight.



**Figure 7: South Elevation - Pad A Mobile Service Structure**

Source: Handbook of ULO Facilities at the Eastern Test Range.

The MSS is equipped with high, medium, and low pressure GN<sub>2</sub>, oxygen and hydrogen vent systems, and a processed water distribution system. The hydrogen services the white room for spacecraft applications. The MSS is also fully equipped with a fire protection system consisting of fireproof materials, fire extinguishing equipment, air horns and a rotating warning beacon.

The MSS is also used to provide limited environmental protection for the vehicle stages during build-up and checkout below level eight. The MSS moves to the launch deck and envelopes the

missile and launch mount. Each level is equipped with fixed and moveable platforms that, when extended, circle the missile and provide a work surface for launch technicians.

Weather curtains protect exposed work areas below Level 8. Above Level 8 is a clean room, also known as the white room. Originally, the clean room was called the "greenhouse" due to the green fiberglass enclosure. The white room completely encloses the third stage and spacecraft, protecting them from adverse weather conditions. The large sliding door, located on the east side of the MSS, is pneumatically sealed providing a tightly-controlled and regulated environment.

The conditioned air is supplied by the White Room Air Conditioning System located in Building 28502.

In 1968, to accommodate the new, long-tank Delta boosters, the MSS was raised 14'-6". The MSS was jacked up and a structural addition, consisting of a new drive system and undercarriage, was placed beneath it.<sup>16</sup>

Delta II modifications to LC 17A were completed by May 1988. Modifications included raising the height of the MSS once again by 20' to accommodate the taller Delta II vehicle. This addition was placed on top of the MSS and included extending the height of the white room. A new hoist was also added to the structure. By 1991, the MSS required emergency rehabilitation to the steel structure. The repairs included sandblasting, welding, corrosion control, and painting most of the joint areas from the ground level up. Both MSSs were tented and sandblasted using almost 800 tons of sand to remove the lead-based paint from the structural steel. The main hoist was removed and a new hoist and refurbishment of the trolley was undertaken.<sup>17</sup>

**Facility 28415: Pad A Digital Image Generation System (HAER No. FL-8-5-D)**

The Air Force Eastern Test Range (AFETR) Digital Image Generation System (DIGS) facility is a missile guidance facility. The building, constructed in 1973, is 341 square feet in size and located approximately 150' northeast of the blockhouse and approximately 435' west of the center point of Pad 17A's launch site. The facility contains theodolite and prism equipment used to calibrate the position of the launch vehicle on the launch deck using geographical survey markers and lines of sight. This data is input into the guidance computers to "locate" the rocket before lift-off.<sup>18</sup> (See photo FL-8-5-D-1 through FL-8-5-D-3)

The building is a mirror image of Facility 28413. The rectangular building measures 11'-4" by 31'-4" and is 9'-6" in height. The building is a reinforced concrete structure with 8" of concrete block infill. Each of the four corners of the building is reinforced with concrete footings to stabilize the building. These footings are 5'-6" square and are 1' thick.

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<sup>16</sup> "New Mission Coming: Pad 17A Readied For Longer Delta," Spaceport News, February 15, 1968.

<sup>17</sup> "Delta II - McDonnell Douglas Developments," late 1980s.

<sup>18</sup> Mr. Albert Grundman, McDonnell Douglas Engineer, interview by authors, Tape recording, Cape Canaveral Air Station, Florida, 13 November 1996.

To completely isolate the sensitive equipment located inside the building, an isolated 23' by 4' by 1' deep reinforced concrete pad was constructed. A smaller secondary isolated prism pier measuring 2' by 2' by 5'-4" is located towards the south end of the building and on the centerline of the larger concrete pad. The foundation of the prism pier is 6' square and 2'-6" deep. The bottom of the foundation is located 6'-8" below the finished floor. A 1" pre-molded expansion joint completely surrounds both the isolated pad and the prism pier from the surrounding concrete floor. (See photo FL-8-5-D-4 and 5)

A 5 ply built-up roof covers the building. Entrance to the building is on the west side through a single flush aluminum door and frame. The north, south, and east elevations feature sliding plywood panels, measuring 4' by 3'-6". The windows, 2'-4" tall, are protected by the plywood panels and are located at a height of 5' above the finished floor. The plywood panels are set into steel tracks, allowing the retraction of the panels for a clear line-of-site to the launch pad and monument markers.<sup>19</sup>

**Facility 28407: Switch Control Building** (HAER No. FL-8-5-E)

The Switch Control Building serves as an electrical interface between the blockhouse and launch pad A. The building, constructed in 1958, is located at the southwest corner of the pad adjacent to the concrete apron. The building is 144 square feet in size and consists of poured reinforced concrete walls, floor and foundation, with a 5 ply built-up roof. (See photo FL-8-5-E-1, 2 and 3)

**Launch Pad B**

**Facility 28402: Launch Pad B<sup>20</sup>** (HAER No. FL-8-5-F) ((See photo FL-8-5-F-23 through FL-8-5-F-32)

**Launcher Building**

The launcher buildings for both pads are parallel, virtually identical to each other and located approximately 550' apart. Each reinforced concrete and steel building is constructed to withstand any potential explosion resulting from the highly flammable and propellant-contaminated atmosphere produced during a launch. The two story rectangular building, constructed in 1959, measures 50' by 59' by 28' in height with 1' thick walls. A cantilevered steel launch deck and flame deflector is located on the building's eastern side. (See photo FL-8-5-F-1 through FL-8-5-F-7)

The launcher building provides a protective shelter for shops, instrumentation, service and transfer equipment, and electrical switching gear. The building is equipped with two rooms, the electronic equipment room and flame deflector valve room. Both rooms measure approximately 16' wide by 25' long. The electronic equipment room houses the electronic equipment used to interface with the launch vehicle. The instrumentation cables, entering into this room from the

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<sup>19</sup> Engineering Drawings, AFETR Digs facility, Theodolite and Prism Shelter, John F. Kennedy Space Center, NASA, Kennedy Space Center, FL, 1972.

<sup>20</sup> The majority of this description came from the Handbook of ULO Facilities at the Eastern Test Range.

instrumentation trench, are connected to electronic equipment located within the launcher building or pass up through the building to the launch deck, umbilical tower and MSS.

The flame deflector valve room controls the deluge water used for sound and flame suppression during a launch. Both rooms are accessible via doors located at ground level. The remaining unused half of the building (the western portion) is completely filled with sand.

The pneumatic complex enclosure and air conditioning unit area are located in two smaller additions on the launcher building's west side. The pneumatic complex, facility 28504, was constructed in 1968. The one-story concrete block addition encompasses 318 square feet. This room houses a hydraulic cart (also known as a mule) for the booster hydraulics non-flight systems. At liftoff the cart is disengaged and the missile's pneumatic system takes over controlling the internal hydraulic system.<sup>21</sup> The air condition unit is also one-story in height, rectangular in plan and constructed of concrete block. The air conditioning unit supplies conditioned air to the trans-stage and spacecraft shroud. (See photo FL-8-5-F-9, 10 and 11)

The launch deck area consists of the cantilevered steel launch deck, steel flame deflector and free-standing fixed umbilical mast. Access to the launch deck, area or "roof" of the building, is possible via three external steel staircases or from the mobile service structure when it is in the service position.

The launch deck, level with the roof of the launcher building, measures 50' wide and extends beyond the launcher building by 38'. The launch deck is constructed of high strength steel girders and beams covered with 1/2" thick steel plates. The launch deck contains the captive test stand and exhaust port, the flame deflector and free-standing fixed umbilical tower.

The launch deck was altered in 1997 to accommodate the next generation rocket. Approximately half of the launch deck, framing members, drop in panels, and flame deflector were removed and replaced with new steel members, 1" steel plate panels with louvers, and two auxiliary flame deflectors. When completed, all exposed steel was again covered with Fondu-Fyre and Martyte (protective blast coatings).

### **Captive Test Stand**

While the launch pads are used for preparing the rocket, the rocket itself rests on a steel captive test stand. The test stand is located at the center point of the cantilevered launch deck. The steel multi-arm structure holds the launch vehicle in an upright position during build-up, check-out and launch sequencing. (See photo FL-8-5-F-8, 12, 13, 14)

The steel captive test stand has been modified several times to accommodate the increased size and weight of the Delta rocket. During the early 1960s, the captive test stand was a low steel ring with several arms. By 1966, the captive test stand was a simple steel structure with four arms. Today, the current generation captive test stand consists of six legs, five permanent and

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<sup>21</sup> Mr. Albert Grundman, McDonnell Douglas Engineer, interview by authors, Tape recording, Cape Canaveral Air Station, Florida, 13 November 1996.

one and three pins. Located on the west side of the captive test stand is the retraction system for leg 4. When the missile lifts off, the arm must clear the rocket's nozzle extension and turbine exhaust stand. When the booster begins to lift from the stand a pin is pulled out and the leg is retracted and held in place so as not to interfere with the nozzles on the solid motor during liftoff.<sup>22</sup>

The deck plates surrounding the captive test stand are labeled with an "N," "S" and "E" for north, south and east respectively. When in place, these three plates allow pad support crew to access the rocket during build-up. Before launching the rocket, the three plates are retracted, exposing the flame deflector below and allowing the exhaust flames to be directed down and away from the launch deck.

The cantilevered steel girders supporting the deck plates range in thickness from 2' at the eastern cantilevered end to 8'-11" at the launcher building connection point. A number of lines extend up and through the cantilevered deck supplying various components within the mobile service structure and umbilical mast. These include a 1" helium line, a 3/4" helium line, a 6" LOX line, a 1" air line, and a 3" demineralized water line.<sup>23</sup>

In 1968, to accommodate the new long-tank Delta space vehicle, the launch deck along with the umbilical tower and mobile service tower were modified. The original 1/4" metal decking was completely replaced with 1-1/2" steel.<sup>24</sup>

### **Flame Deflector**

The flame deflector is located directly below the launch mount. During a missile launch, the launch blast is directed down to the concrete flame bucket which then sends the blast eastward. A water deluge system, located throughout the launch deck area and the flame deflector, is used to cool and protect the launch equipment from the extreme heat of the launch blast. Several water stanchions, located on the launch deck, focus their spray towards the launch mount. Below the launch deck, the flame deflector is equipped with numerous pipes, sprayers and nozzles. The main supply header supplies 6 sleeves (ranging in size from 10" to 16" in diameter) with water which then branch to 4" pipe sleeves and 2-1/2" pipe nozzles covering the entire deflector face.<sup>25</sup> A drain point captures the water from all areas of the pad and directs it towards the retention pond. The drain point is also used as a collection tool in the case of a fuel spill.

The flame deflector itself is 33' wide and parabolically shaped directing the exhaust to east. It is constructed of 1-1/4" steel backed with concrete and supported with steel girders. Water outlets on the face of the deflector are fed by a system of deluge manifolds.<sup>26</sup>

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<sup>22</sup> Mr. Albert Grundman, McDonnell Douglas Engineer, interview by authors, Tape recording, Cape Canaveral Air Station, Florida, 13 November 1996.

<sup>23</sup> Captive Test Stands 17A and 17B Steel Deck Framing Engineering Drawings, Aerojet-General Corporation, Azusa, CA, 1956.

<sup>24</sup> "New Mission Coming: Pad 17A Readied For Longer Delta."

<sup>25</sup> Captive Test Stands 17A and 17B Flame Deflector Piping Engineering Drawings, Aerojet-General Corporation, Azusa, CA, 1956.

<sup>26</sup> Handbook of ULO Facilities at the Eastern Test Range, 6.36.

In 1997, the flame deflector underwent modifications to support the next generation Delta rocket. Modifications include the replacement of primary and secondary structural steel members and decking along the top of the launch deck, the addition of a walled concrete flume, and two auxiliary flame deflectors with moveable flame ducts. (See photo FL-8-5-F-15, 16, and 17)

The two new fixed auxiliary flame deflectors with moveable ducts angle off from the launch deck at 60 degrees from center line of the captive test stand in both the northwest and southwest directions. The two fixed auxiliary flame deflectors are approximately 9' wide by 20' long and stand the height of the launcher building. The steel auxiliary flame deflectors are constructed of structural steel members coated with a 10" pneumatically applied shotcrete slab over fibrous mesh with an additional 2" of Fondu-Fyre on the surface for blast protection. The flame deflectors within the auxiliary units curve down from the top of the launch deck and terminate approximately 5' above grade where they mate with the two new moveable flame ducts.

The moveable flame ducts are large steel "boxes" measuring approximately 17' wide by 23' long by 18' tall. The ducts are mounted on 15 ton stub-axle rail-car wheels and Hillman rollers on rails set approximately 5' apart. The two moveable flame ducts are brought up to the launcher building, mated with the two auxiliary flame deflectors, then anchored and locked in place. During testing and launch, the blast gases and flames are directed down through the main flame deflector and both auxiliary flame deflectors and moveable flame ducts and out through huge concrete free-standing ducts. The concrete free-standing ducts are 1' thick by 16'-6" high. The "roof" of the duct spans 16'.<sup>27</sup>

### **Retention Pond**

The retention pond measures 60' wide by 130' long and lined with concrete. The concrete retention pond is connected to the launch pad area by a 230' long concrete flume. During launch, the flume channels the deluge water from the launch deck to the retention pond located on east side of the complex. After every launch, the deluge water in the basin was tested for fuel contamination and, if necessary, neutralized or hauled away as toxic waste.

The flume was modified and enclosed in 1997 to assist in containing and directing the hazardous gases flames, and deluge water generated by the rocket launch. New 18" thick by 19'-2" high concrete walls were built on top of the original concrete flume slab. The "roof" of the new flume spans 30' across. The angle area between the original concrete flume and new vertical concrete walls has been filled with sand and compacted.<sup>28</sup> (See photo FL-8-5-F-18 and 19)

### **Umbilical Mast**

The umbilical mast (UM) is a structural steel tower located in the southeast corner of the launch deck. The function of the UM is as a service provider and the retractable booms supply electrical

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<sup>27</sup> "Space Launch Complex 17B Delta III Modification Drawings," McDonnell Douglas Aerospace - Cape Canaveral Air Station, BRPH Architects-Engineers, Inc., Melbourne, FL, August 10, 1996.

<sup>28</sup> Ibid.

power, instrumentation, propellants, pneumatics and conditioned air to the launch vehicle or payload.<sup>29</sup> (See photo FL-8-5-F-20 through FL-8-5-F-22)

Originally, the UM was a simple retractable steel structure located in the southeast corner of the launch deck. Two large retractable umbilical cords and several smaller cords provided the various connections required to support the missile. However, due to the continuous development of the Delta and Thor rockets a new umbilical mast was constructed in 1969. The new UM was a fixed-in-place open steel-framed structure measuring 133' tall. In conjunction with the numerous missile connections, the new UM also contained 15 platforms and work levels, ladders and an elevator. The new UM also contained two two-level retractable steel walkways at the ninth and twelfth levels to provide emergency access capability to the trans-stage sections and the spacecraft shroud.<sup>30</sup> When not in use, the pneumatically-controlled retractable walkways are stowed against the UM's west face.<sup>31</sup>

The bottom three levels of the UM (beginning at launch deck height) were enclosed with steel plate coverings to protect it against the missile's blast. A new foundation of steel girders encased in concrete replaced the original steel foundation for the UM. Additional modifications were necessary on the launch deck and apron to accommodate the numerous connections required to support the missile.<sup>32</sup> The numerous launch vehicle connections are possible through the main cabletray on the UM's north side. Two cooling air ducts extend up the UM's south face along with the GN<sub>2</sub> and GH<sub>e</sub> lines. All communication wiring is contained within this conduit which is purged with GN<sub>2</sub>.

In 1970, the UM for Pad 17B was raised to accommodate the new, longer Delta rocket. Today, the shrouded UM contains an electrical umbilical, a propulsion umbilical, and a digzair umbilical. The digzair umbilical was used to provide airflow into the guidance section.<sup>33</sup>

In 1997, the UM was once again modified to accommodate a next generation rocket. This time, fourteen of the sixteen levels underwent some type of modification. The majority of the work consisted of removing existing steel framing members, steel grating, handrails and posts, receptacles, conduit and associated conductors. Replacement elements included new 1" fixed and removable galvanized steel grating, new fixed steel handrails and removable aluminum handrails, cable trays, temperature/humidity transmitters, receptacles, lightening circuits, hepa filters, LH<sub>2</sub> and LOX piping and valves, and the relocation of compressed air risers. Typically, the modifications were confined to the east side of the UM. Levels 8, 11, 12, and 13 approximately doubled in size with an L-shaped platform added to the east side. These extended

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<sup>29</sup> A Dictionary of Astronautics, 299.

<sup>30</sup> Handbook of ULO Facilities at the Eastern Test Range, 6.36.

<sup>31</sup> Ibid., 6.38.

<sup>32</sup> "SM-46383 Fixed Umbilical Mast," Missile & Space Systems Division, Douglas Aircraft Company, Inc., Santa Monica, CA, January 1965, Architectural Descriptions and Drawings, Phase 1.

<sup>33</sup> Mr. Albert Grundman, McDonnell Douglas Engineer, interview by authors, Tape recording, Cape Canaveral Air Station, Florida, 13 November 1996.

platforms allow launch personnel to access the new Delta III Rocket during launch preparations.<sup>34</sup>

### **Liquid Hydrogen Storage Area**

In 1997, a new liquid hydrogen (LH<sub>2</sub>) storage area was constructed southeast of the launcher building. The original asphalt road servicing the RP-1 fuel storage tanks was extended to accommodate the new storage area. The road makes a loop to allow tanker trucks to approach the storage area from two directions. The storage area consists of a LH<sub>2</sub> storage tank, concrete pad, blast wall and earthen berm, and numerous control panels and piping.

The LH<sub>2</sub> is contained within a dewar vessel, a double-lined tank separated by an evacuated space. This type of vessel is used for liquid air, hydrogen or helium.<sup>35</sup> The tank is supported by two concrete tank saddles mounted to on a 96' long concrete pad. Protection of the LH<sub>2</sub> is provided by a 20' tall by 96' long C-shaped reinforced concrete blast wall which is then, further reinforced with a compacted earthen berm. The earthen berm slopes down to cover a horizontal distance of 29'.

The eastern end of the storage area contains dewar valve and instrument control panels, gaseous nitrogen (GN<sub>2</sub>) and gaseous helium (GH<sub>e</sub>) purge and control panels, as well as tanker offload control panels.

### **Facility 28417: Pad B Mobile Service Structure (HAER No. FL-8-5-G)**

The mobile service structure (MSS) stands 133' tall, weighs approximately 500,000 pounds, and is predominately rectangular in shape. The structure is constructed of open steel-framing with nine retractable servicing and checkout levels for vehicle preparation, checkout, simulated flight and sequence testing, and countdown preparation.<sup>36</sup> (See photo FL-8-5-G-1 through FL-8-5-G-18)

The MSS, mounted on drive truck assemblies, is used only during the build-up and servicing of the launch vehicle. The four truck assemblies are mounted on steel rails set 58' apart. Each of the drive truck assemblies measures 49" in height, between 70" and 98" in width, 100" in length, weighs 25,820 pounds and travels at speeds between 0-50 feet per minute<sup>37</sup>

Shortly before launch the MSS is moved to its stowed position, approximately 400' to the northwest, and "locked" down using four concrete guying anchors and pins. Four additional guying anchors are located an equal distance from the launch deck for locking the MSS in place during servicing.

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<sup>34</sup> "Space Launch Complex 17B Delta III Modification Drawings," McDonnell Douglas Aerospace - Cape Canaveral Air Station, BRPH Architects-Engineers, Inc., Melbourne, FL, August 10, 1996.

<sup>35</sup> Nayler, A Dictionary of Astronautics, p 65.

<sup>36</sup> International Reference guide to Space Launch Systems, 212.

<sup>37</sup> Technical Manual: NASA/DELTA d17.15.31.0, Section 1.

Unlike the mobile service structures used at other CCAS launch complexes, this MSS moves to and from the launch deck from the western side of the complex. The MSS moves completely over the launcher building and straddles the launch deck when it is in the service position. The eastern face of the MSS opens and envelopes the missile and launch mount. Once enclosed, the platforms are lowered and the white room door closes to protect the missile from the environment. The majority of the mobile services structures used at CCAS moved to and from the launch deck from an easterly direction. The MSS would travel to the launch deck from the direction of the retention pond. When in the service position, the MSS would straddle the flume and flame bucket.

The primary functions of the MSS are to erect and mate the first stage booster to the launch mount as well as the build up and mating of the second stage, third stage, and payload. Originally, a 10-ton hoist and 3-ton jib hoist were mounted on a bridge atop the MSS. The two hoists are used to lift heavy equipment and maneuver the different stages into place. A one and one half ton monorail hoist was located on Level 1 for lifting equipment to the launcher deck. The cranes have been reinforced, upgraded, and expanded over the years to accommodate larger and heavier vehicles. The MSS's nine levels provide numerous work platforms. Access to the different levels is possible by either a one ton capacity elevator, stairs from the launcher deck or from the umbilical mast via two crossovers at Levels four and eight.

The MSS is equipped with high, medium, and low pressure GN<sub>2</sub>, oxygen and hydrogen vent systems, and a processed water distribution system. The hydrogen services the white room for spacecraft applications. The MSS is also fully equipped with a fire protection system consisting of fireproof materials, fire extinguishing equipment, air horns and a rotating warning beacon.

The MSS is also used to provide limited environmental protection for the vehicle stages during build-up and checkout below level eight. The MSS moves up to the launch deck and envelopes the missile and launch mount. Each level is equipped with fixed and moveable platforms that, when extended, circle the missile and provide a work surface for launch technicians.

Weather curtains protect exposed work areas below Level 8. Above Level 8 is a clean room, also known as the white room. Originally, the clean room was called the "greenhouse" due to the green fiberglass enclosure. The white room completely encloses the third stage and spacecraft, protecting them from all outside weather conditions. The large sliding door, located on the east side of the MSS, is pneumatically sealed providing a tightly-controlled and regulated environment. The conditioned air is supplied by the White Room Air Conditioning System located in Building 28502.

In 1970, to accommodate the new long-tank Delta boosters, the MSS for Pad I7B was raised 22'. The entire MSS was hydraulically lifted and a new steel section placed underneath.<sup>38</sup> By the mid 1980s, the MSS was undergoing modifications once again to support the Delta II launch vehicle. Modifications were made to the steel structure and to the air-conditioning system. Phase 1

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<sup>38</sup> Myers, Tom, "14-Story Gantry Gets a Lift," Today, 26 September 1970.

modifications to the launch complex were completed in May 1988. By 1989, the MSS was again raised 20' to accommodate the taller Delta II vehicle. This addition was placed on top of the MSS and included extending the height of the white room. A new hoist was also added to the structure. In 1991 the MSS underwent significant repairs. These repairs included sandblasting, welding, replacement of corroded members, and painting most of the joint areas from the ground level up. Additional work included the installation of new airlocks for the white room, a new interior bridge crane, new elevator and main hoist, the repair of the solid rocket motor hoist sheaves, lightning protection, and turtle light shields.<sup>39</sup>

In 1997, the existing deck plates and fold-down "diving board" platforms on several levels were removed and replaced to accommodate the new Delta II rocket. Also included within the upgrade's scope of work were new gaseous hydrogen and helium lines, electrical conduits, work platform configurations, handrails, and a new bridge crane. The bridge crane is used to hoist and assembly the rocket stages.

**Facility 28408: Electrical Distribution Building (HAER No. FL-8-5-H)**

The Electrical Distribution Building, commonly called a Tip Shack, serves as an electrical interface between the blockhouse and launch pad B. The building, constructed in 1958, is located at the northwest corner of the pad adjacent to the concrete apron. The building is 38 square feet in size and consists of poured reinforced concrete walls, floor and foundation, with a 5 ply built-up roof. (See photo FL-8-5-H-I through FL-8-5-H-4)

**Facility 28413: Pad B Digital Image Generation System Building (HAER No. FL-8-5-I)**

The Air Force Eastern Test Range (AFETR) Digital Image Generation System (DIGS) facility is a missile guidance facility. The building, constructed in 1973, is 341 square feet in size and located approximately 150' southeast of the blockhouse and approximately 435' west of the center point of Pad 17B's launch site. The facility contains theodolite and prism equipment used to calibrate the position of the launch vehicle on the launch deck using geographical survey markers and lines of sight. This data is entered into the guidance computers to "locate" the rocket before lift-off.<sup>40</sup> (See photo FL-8-5-I-1 and 2)

The building is a mirror image of Facility 28415. The rectangular building measures 11'-4" by 31'-4" by 9'-6" in height. The building is a reinforced concrete structure with 8" of concrete block infill. Each of the four corners of the building is reinforced with concrete footings, measuring 5'-6" square with a 1' thickness, to stabilize the building.

To completely isolate the sensitive alignment equipment located inside the building, an isolated 23' by 4' by 1' deep reinforced concrete pad was constructed. A smaller secondary isolated prism pier measuring 2' by 2' by 5'-4" is located towards the south end of the building and on

<sup>39</sup> "Delta II - McDonnell Douglas Developments."

<sup>40</sup> Mr. Albert Grundman, McDonnell Douglas Engineer, interview by authors, Tape recording, Cape Canaveral Air Station, Florida, 13 November 1996.

the centerline of the larger concrete pad. The foundation of the prism pier is 6' square and 2'-6" deep. The bottom of the foundation is located 6'-8" below the finished floor. A 1" pre-molded expansion joint completely surrounds both the isolated pad and the prism pier from the surrounding concrete floor. (See photo FL-8-5-I-3 through FL-8-5-I-5)

A 5 ply built-up roof covers the building. Entrance to the building is on the west side through a single flush aluminum door and frame. The north, south, and east elevations contain 4' by 3'-6" sliding plywood panels. The 2'-4" tall windows protected by the plywood panels are located at a height of 5' above the finished floor. The plywood panels are set into steel tracks to allow for the retraction of the panels for a clear line-of-site to the launch pad and monument markers.<sup>41</sup>

### **Launch Pad Support Facilities**

There are several launch support facilities located at the complex, these include: fuel storage facilities, a liquid oxygen (LOX) storage facility, gaseous nitrogen facilities, a gaseous helium facility, an air conditioning facility, a storage building, and a change room.

#### **Facility 28403: Alignment Building (HAER No. FL -8-5-J)**

The one-story building is located approximately 170' directly east of the blockhouse. The building, constructed in 1970, was originally used as a missile guidance storage facility. Today, the building is used primarily for equipment storage.

The rectangular plan building contains 800 square feet and is constructed with a reinforced concrete foundation, concrete block walls and a built-up medium pitched shed roof. The west side of the building has two sets of double metal doors with low-pitched concrete ramps. A roll-up metal door with steel shelf is located between the two sets of doors for equipment distribution. The west side also contains a four-light metal window. The interior of the building is divided into two areas: north and south. The northern area is used for office space and equipment distribution. The south room contains an alignment equipment stand. (See photo FL-8-5-J-1 through FL-8-5-J-5)

#### **Facility 28404: Storage Building (HAER No. FL-8-5-K)**

The small one-story storage building is located within the GN<sub>2</sub> and GH<sub>4</sub> tank farm. This building was constructed in 1958 and contains 147 square feet. The building is used as a warehouse supply and equipment base for the launch pads. (See photo FL-8-5-K-1 through FL-8-5-K-3)

The building is constructed with a poured concrete foundation and ceiling, concrete block walls, and a built-up flat roof. A single flush panel door is located on the east side of the building.

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<sup>41</sup> AFETR Digs facility, Theodolite and Prism Shelter Engineering Drawings, John F. Kennedy Space Center, NASA, Kennedy Space Center, FL, 1972.

**Facility 28409: Change & Rest House (HAER No. FL-8-5-L)**

Building 28409 was constructed in 1968 and contains 900 square feet. The one-story building is located east of the blockhouse midway between Pads A and B. The building was used as a break room by the pad support crew until upgrades to the missile required abandonment of the building. A new break room was constructed west of the blockhouse. The building is currently used for escape suit preparation when fueling of the second stage occurs.

The building measure 30' by 30' and is constructed with a poured concrete frame and concrete masonry unit infill. Two aluminum doors provided access into the building. The building was originally outfitted with two aluminum three light awning windows with concrete sills and lintels. The windows have since been covered with plywood and air conditioning units have been installed. The low-pitched built up roof contains a single power roof ventilator. (See photo FL-8-5-L-1 and 2)

The interior of the building was divided into the entry vestibule with access to the shower room, a change room, locker room, enclosed toilet room, and enclosed acid suit storage room. All of the rooms except the shower room were constructed with a concrete floor coated with a sealer and concrete masonry unit walls. The shower room had a ceramic tile floor and concrete masonry unit walls. (See photo FL-8-5-L-3 and 4)

**Facility 28422: Chiller Building (HAER No. FL-8-5-M)**

The Chiller building was constructed in 1994 and serves as an air conditioning facility. The high-bay type building is rectangular in plan and contains 1,184 square feet. The building was constructed with a concrete foundation, concrete masonry unit walls and a flat roof with a parapet on three walls. The exterior walls have been sheathed with a synthetic exterior finish material (e.g. Z-Foam or Dryvit.) The roof extends out from the west facade by approximately 4'. The west elevation is equipped with three roll-up overhead doors and a single steel personnel door. (See photo FL-8-5-M-1 through FL-8-5-M-7)

**Facility 28502: White Room Air Conditioning Building (HAER No. FL-8-5-N)**

Both MSS contain white rooms that are used to protect the missile's sensitive payload from environmental conditions. The conditioned air supplied to both white rooms is supplied from this one facility located between pads A and B. (See photo FL-8-5-N-1 through FL-8-5-N-4)

The building, originally constructed in 1969, contains 1,144 square feet. Three walls (north, east, south) are constructed with poured reinforced concrete walls, 1' thick, extending above the roof line by approximately 2'. The fourth wall is constructed of concrete block. The building is covered with a low-pitched built-up shed roof. The main entrance, located on the building's west

side, consists of a single metal door and an overhead metal door on opposite ends. The building also contains two large metal louvered vents, one on the eastern side and one on the western side.

The facility supplies conditioned air to the MSS through a duct system. In 1969, the insulated ductwork extended eastward above ground and then branched off towards each pad. Once the ductwork reached the concrete pad surrounding the launch deck, it extended down into a covered trench and terminated in the launcher building. Connections within the launcher building then supplied the MSS with conditioned air for the white room. This one facility was capable of supplying enough conditioned air for both white rooms simultaneously. The air conditioner had two 40 ton compressor units and one 7,500 cfm air handling unit.<sup>42</sup>

Today, the MSS white rooms are still supplied with conditioned air. The Chiller Building (Building 28422) is located adjacent to this building. Several stainless steel pipes extend from Building 28422 terminating in a "T" which then continues on to both launch pads. (verify)

### **Fueling System**

A two-part propellant system was used to launch the Delta missile: fuel and oxidizer. The fuel originally used to launch the Delta missile was RJ-1, a liquid fuel that is denser than the kerosene-based fuel RP-1. The oxidizer, Liquid Oxygen (LOX), is a highly explosive light blue, transparent liquid, considerably more flammable than gaseous oxygen.<sup>43</sup> Both RJ-1 and LOX require careful handling and storage in steel and aluminum tanks and distribution lines.

### **Facility 28405: LOX Storage and Pumping Facility (HAER No. FL-8-5-O)**

The Liquid Oxygen (LOX) facility, constructed in 1967, was originally located approximately 375' east of the blockhouse, centered between the two launch pads. Both pads use liquid oxygen as an oxidizer for the launch vehicles. The facility consisted of a U-shaped concrete blast wall and LOX storage vessel. The LOX was pumped out of the vessel through stainless steel pipes to cross piping running perpendicular between the two pads. (See photo FL-8-5-O-1 through FL-8-5-O-5)

Today, the LOX facility is located approximately 425' in front (east) of the blockhouse, centered between the two launch pads and adjacent to the Medium Pressure Gas Storage Facility. The LOX facility is constructed with a L-shaped concrete pad approximately 80' long by 22' wide with the "L" portion measuring 33' in width. A 6" concrete curb encloses the pad and serves as a partial containment system. The single 28,500 gallon tank is approximately 50' long, weighs approximately 35,000 pounds and is constructed of two nested vessels. The outer vessel is aluminum and the inner vessel is stainless steel separated by a vacuum insulation space. The tank is supported low to the ground on four steel and concrete pedestals.

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<sup>42</sup> Ibid., 6.09.

<sup>43</sup> R.E. James, ed., Handbook of Liquid Propellants (Martin Company Cocoa Division, 1961), 10.

Located to the south of the LOX tank is the tank end complex surrounded by a 10' high C-shaped concrete blast wall. The tank end complex contains the pressurization regulators, numerous vent, bypass, load and control valves, and the pressurization line filter, all used for LOX distribution and monitoring.<sup>44</sup> Other gauges include a liquid level gauge, a vacuum gauge and protective hood; a liquid transfer line, and vacuum line.

Located behind the blast wall is a 3" LOX drain extending to the LOX evaporation pond, receptacles, switch plates, and 120 volt line. A 12" diameter standard steel pipe sleeve extends through the blast wall approximately 24" about grade. A 2' by 3' catch basin is located below the pipe sleeve on the outside of the blast wall. In addition to the transfer equipment and electrical equipment, the facility contains ten 300 watt reflector lights. The 7' tall light standards are located around the perimeter of the facility.

A flow control valve complex is located beneath the deck plates of both pad A and pad B launcher buildings. The complex contains numerous types of loading and unloading valves for LOX distribution.<sup>45</sup>

### **De-LOX Pumping Station**

Each pad had a De-LOX pumping station located towards the "inside" of each launch pad. A 4" drain line ran from the launch pad to the pumping station. The pumping stations were recessed below grade with a 6" pipe set into a 10" sleeve. Each De-LOX pumping station contained a 6" drain line which connected the station to the LOX evaporation pond. The two 6" drain lines connected at midpoint between the two pads and became one 6" drain line which dumped into the pond. Each individual drain line contained two expansion loops (14' by 14' by 6') to allow the lines to expand and contract as needed without rupturing.

### **LOX Evaporation Pond**

The LOX evaporation pond measured 20' square with angled side walls and an unpaved sand bottom. An inlet drain connected the evaporation pond with the De-LOX pumping station. The pond is no longer needed and has been backfilled, mulched and seeded.

### **Facility 28406: Fuel Storage and Pumping Facility (HAER No. FL-8-5-P)**

When the launch complex was originally constructed in the late 1950s, both launch pads shared a single RP-1 fuel storage facility. RP-1, a kerosene based fuel, was, and still is, used in the missile's first stage. The original facility was located midway between both pads and

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<sup>44</sup> Handbook of ULO Facilities at the Eastern Test Range, 6.13.

<sup>45</sup> Ibid., 6.14.

approximately 170' east of the blockhouse. The facility contained a single 6,000 gallon stainless steel storage vessel surrounded by concrete blastwalls. Stainless steel piping distributed the RP-1 to both pads. By 1966 the single RP-1 tank was replaced by two storage facilities, one at each pad. The original defuel pump station, defueling channel and disposal pond associated with this pad remained in use. (See photo FL-8-5-P-1 through FL-8-5-P-4)

Facility 28406 is located adjacent to and north of LC 17A. The storage facility consists of a concrete pad measuring 23' by 56' with an U-shaped concrete wall on the north end. A 4" concrete curb encloses the pad and serves as a partial containment system.<sup>46</sup> Two RP-1 fuel tanks are supported by steel webbed cradles bolted to the concrete pad.

The C-shaped blast wall is approximately 10' tall with 8' "wing" walls. The blast wall shields the skid-mounted fuel transfer unit, the explosion proof circuit breaker for the tank end unit pump motor, associated receptacles and switches, and a 3" drain line to the fuel drain channel. The fuel channel directs any liquid within the storage area to the fuel collection pond located approximately 30' to the east. A single standard steel pipe sleeve, 14" in diameter, extends through the blast wall at 24" above grade. Ten 300 watt lights are located around the perimeter of the facility. The light standards are 7' tall.<sup>47</sup>

The fuel was pumped from the RP-1 storage tank to the launcher building and distributed through the UM to service the launch vehicle. A new circular drive was added to allow vehicular access to the storage area. The fuel storage area is still in use today.

### **Fuel Disposal Pond**

Each launch pad contained a fuel disposal pond in the event of an emergency fuel dump from the missile. LC 17A's disposal pond was located 150' from the center point and north of the launch mount. The pond was 30' square, constructed with a 4" reinforced concrete slab and angled sides, and recessed approximately 5' into the earth.

A defueling trench, connected to the De-Fueling Pumping Station, emptied into the corner of the fuel disposal pond. The defueling trench was constructed of 2-1/2" shotcrete over 4 x 4-13-13 gage mesh. The bottom of the trench was lined with an 8" glazed drain tile.

By 1973, the fuel disposal pond was no longer needed and was backfilled, mulched and seeded. In 1997, the fuel disposal pond and defueling trench were completely removed, backfilled, mulched and reseeded.

### **Facility 28503: Fuel Storage and Pumping Facility (HAER No. FL-8-5-Q)**

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<sup>46</sup> Engineering Drawings: Fuel Storage Tank Pads and Details, Launch Complex 17, John F. Kennedy Space Center, Merrit Island, FL, 1965.

<sup>47</sup> Engineering Drawings: Launch Complex 17, IOC Fuel Storage Facilities, Fuel RJ-1, John F. Kennedy Space Center, Cocoa Beach, FL, 1965.

When the launch complex was originally constructed in the late 1950s, both launch pads shared a single RP-1 fuel storage facility. RP-1, a kerosene based fuel, was, and still is, used in the missile's first stage. The original facility was located midway between both pads and approximately 170' east of the blockhouse. The facility contained a single 6,000 gallon stainless steel storage vessel surrounded by concrete blastwalls. Stainless steel piping distributed the RP-1 to both pads. By 1969, the single RP-1 tank was replaced by two storage facilities, one at each pad. The original defuel pump station, defueling channel and disposal pond associated with this pad remained in use. (See photo FL-8-5-Q-1 through FL-8-5-Q-4)

Facility 28503 is located adjacent to and south of LC 17B. The storage facility consists of a concrete pad measuring 23' by 56' with an U-shaped concrete wall on the north end. A 4" concrete curb encloses the pad and serves as a partial containment system.<sup>48</sup> Two RP-1 fuel tanks were supported by steel webbed cradles bolted to the concrete pad. The C-shaped blast wall is approximately 10' tall with 8' "wing" walls. The blast wall shields the skid-mounted fuel transfer unit, the explosion proof circuit breaker for the tank end unit pump motor, associated receptacles and switches, and a 3" drain line to the fuel drain channel. the fuel channel directs any liquid within the storage area to the fuel collection pond located approximately 30' to the east. A single 14" diameter standard steel pipe sleeve extends through the blast wall at 24" above grade. Ten 300 watt lights are located around the perimeter of the facility. The light standards are 7' tall.<sup>49</sup>

The fuel was pumped from the RP-1 storage tanks to the launcher building and distributed through the UM to service the launch vehicle. A new circular drive was added to allow vehicular access to the storage area. The fuel storage area is still in use today.

### **Fuel Disposal**

The De-fueling Pumping Station was located adjacent to the launch pad. The station was a recessed concrete containment facility measuring approximately 2' deep and equipped with pumping equipment. In the event of an emergency fuel dump, the fuel is immediately off-loaded and pumped through a trench to the pad's disposal pond.

LC 17B's disposal pond was located 150' from the center point and south of the launch mount. The pond was 30' square, constructed with a 4" reinforced concrete slab and angled sides, and recessed approximately 5' into the earth.

A defueling trench, connected to the De-Fueling Pumping Station, emptied into the corner of the fuel disposal pond. The defueling trench was constructed of 2-1/2" shotcrete over 4 x 4-13-13 gage mesh. The bottom of the trench was lined with an 8" glazed drain tile.

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<sup>48</sup> Engineering drawings: Fuel Storage Tank Pads and Details, Launch Complex 17, John F. Kennedy Space Center, Merrit Island, FL, 1965.

<sup>49</sup> Engineering Drawings: Launch Complex 17, IOC Fuel Storage Facilities, Fuel RJ-1, John F. Kennedy Space Center, Cocoa Beach, FL, 1965.

By 1973, the fuel disposal pond was no longer needed and was backfilled, mulched and seeded. The outline of the pond remains visible. In 1997, the fuel disposal pond and defueling trench were completely removed, backfilled, mulched and reseeded.

**Facility 28419: Liquid Nitrogen Tank (HAER No. FL-8-5-R)**

The complex was serviced by two gaseous nitrogen ( $\text{GN}_2$ ) and gaseous helium ( $\text{GH}_e$ ) systems -- high pressure and medium pressure.  $\text{GN}_2$  and  $\text{GH}_e$  were/are both used at the launch complex and supplied by two systems -- one a high pressure system, the other a medium pressure system. Both  $\text{GN}_2$  and  $\text{GH}_e$  are used to purge supply lines and provide sensitive equipment with an oxygen-free environment thereby eliminating the possibilities of sparks. The original high pressure system (HP) was located southwest of the blockhouse and adjacent to the Shop/Ready Room. (The current location of Building 36004). The tank farm consisted of a small one-story reinforced concrete building housing the servicing and distribution equipment and tanks surrounded on three sides by earth berms. HP  $\text{GN}_2$  was stored in three tanks with a total capacity of 46,464 scf (standard cubic feet). By 1973, the Locker and Storage facility replaced the  $\text{GH}_e$  facility. The tanks were charged at either the primary charging panel or at the secondary charging panel located at the medium pressure tank farm. Both the  $\text{GN}_2$  and  $\text{GH}_e$  were distributed to the launch pads via 1-1/2" stainless steel piping. A remote control console was located in the blockhouse. Pressurization /control consoles were located at each of the launcher decks. Both  $\text{GN}_2$  and  $\text{GH}_e$  were pumped to the launch vehicle via umbilical tower connections.  $\text{GN}_2$  was brought to the complex by a 10,000 psi (pounds per square inch) mobile tanker to the 6000 psi system. Then distributed through to 6000 psi gas system piping to riser system on MSS and distributed out to consoles, heat exchanger and retropanels.

The second  $\text{GN}_2$  and  $\text{GH}_e$  pressurization facility (currently Building 28410 area) is located midway between pads A and B. Medium pressure (MP)  $\text{GN}_2$  (2200 psi) was used at the launch pad for vehicle servicing, purging, instrumentation, pneumatics, propellant tank pad/pressurization. The farm contained eight tanks, supported on concrete stanchions, with a total capacity of 487,000 scf at 22000 psi.<sup>50</sup> Medium pressure  $\text{GN}_2$  was also pumped to the Liquid Oxygen (LOX) tank end complex. Additional supplies of  $\text{GN}_2$  were delivered to the MP tank farm either by tank trailers or pumped from the high pressure gas facility. MP  $\text{GN}_2$  is distributed to LOX tank end complex through the HP gas trench which serviced both launch decks. Pneumatic equipment room controlled the distribution and reduction of the gas. The MP  $\text{GN}_2$  was further reduced to 5 psi for use in various consoles and panels on the MSS for purging, pressurization, checkout and calibration of equipment.

Today, the complex consists of two stacks of two  $\text{GH}_e$  tanks and 6 tanks of  $\text{GN}_2$ . Two earthen berms are located on either side of the LOX,  $\text{GN}_2$ , and  $\text{GH}_e$  complex to provide blast protection during a launch. (See photo FL-8-5-R-1 through FL-8-5-R-6)

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<sup>50</sup> Ibid., 6.11.

Occasionally, the LOX was dumped from the missile. The contaminated LOX was pumped to a square shaped LOX pond east of the LOX facility. In 1962, the poured concrete pond with sloped sides was broken into pieces, backfilled, mulched, and seeded.

### **Administrative Support Facilities**

#### **Facility 28425: Security Building (HAER No. FL-8-5-S)**

The original security building at LC 17 consisted of a small wood-frame security hut. The one-man guard house contained half-height windows on three sides with a wooden door on the fourth. The security hut was located along the access road west of the Machine Shop Building.

In 1993, LC 17 underwent security upgrades. Upgrades included renovations to the perimeter fencing as well as construction of a new security building. The security building is rectangular in plan with an L-shaped hipped roof. The longer leg of the "L", extending across the front (northwest) side of the building, originally was designed to provide an environmental shelter for four controlled entry booths and two exit turnstiles. In lieu of the booths and turnstiles, a 10' high grounded chainlink fence topped with barbed wire extends the length of the L and continues around the entire complex.

The complex contains two entry points. The main entry point is located at the eastern terminus of Lighthouse Road adjacent to the Security Building. The entry point consists of a 10' high by 40' wide chainlink gate extending across the two-lane entry road. The gate is on wheels set into a steel channel. This controlled entry point secures the complex from both pedestrian and vehicular traffic. As a safety procedure, all persons and vehicles entering the complex must check in at the entry control booth, state which pad they are going to and receive a badge. Any movement between pads requires checking in again with the security guards. In the event of an accident at either pad, the identification of all persons will be known and their last whereabouts identified -- A or B. A second gate is located on the northeast side of the complex and allows access onto Complex 18.

The security building, completed in 1995, is one-story in height, contains approximately 420 square feet and measures 32'-6" by 13'-4". The L-shaped leg measures approximately 34' in length. The building is constructed of 8" concrete masonry units covered with 2" thick synthetic exterior finish material (e.g. Z-Foam or Dryvit.) The building is divided into two rooms: the entry control room, and the communication equipment room. An 8" concrete block wall separates the two rooms. No interior access is possible between the two rooms. (See photo FL-8-5-S-1 through FL-8-5-S-5)

The entry control room is approximately 13' by 14' and contains a single toilet room and storage closet. The room contains two hollow metal entry doors, and three walls of 5/16" burglar resistant glass windows. The floor is covered with vinyl composition tile. The walls are exposed concrete block. (See photo FL-8-5-S-6 and 7)

The communications equipment room is located on the east end of the building with a single entry door on the south side. The room's 5" thick concrete floor is located 18" below grade. The

room is equipped with a 24" square raised computer access floor and acoustical tile ceiling. The concrete block walls remain exposed.<sup>51</sup>

**Facility 36001: Machine Shop/Launch Operations Office (HAER No. FL-8-5-T)**

The combination Machine Shop/Launch Operations Office (previously known as the Ready Room and Shop Building) is located approximately 100' northwest of the blockhouse. The building, originally constructed in 1958, houses administrative, engineering, and communication space as well as miscellaneous shop space.

Originally, the building contained the Machine Shop only. The building was rectangular in plan measuring 50' by 60'. The high-bay building was constructed using a poured concrete frame with concrete block fill, exposed steel joists, and a flat roof. A monorail was installed in the building to lift and place heavy objects and equipment. The floor was a poured concrete.

By 1964, plans were already underway to expand the building to include a Launch Operations Office. The expansion consisted of an addition connected to the northwest corner of the Machine Shop to house the engineering support office, mechanical room, and additional restrooms. The one-story addition measured 86'-8" long by 30'-8" wide. The one-story addition was constructed with concrete block, exposed concrete block pilasters, and a poured concrete foundation. (See photo FL-8-5-T-1 through FL-8-5-T-5)

Today, the combination Machine Shop/Launch Operations Office has been renovated numerous times to accommodate the ever-growing number of administrative and engineering offices required to support the Delta launches. Total square footage equals 5,456 square feet. (See photo FL-8-5-S-6 through FL-8-5-S-8)

The original overhead door has been removed and filled with concrete block. A second overhead door was located on the building's north side. A metal awning currently spans across this opening with a single door and window below. Access into the building is possible through numerous aluminum and glass storefront doors and flush panel steel doors. The building retains the original aluminum four-light awning windows. Mechanical equipment and several ventilators are located on the roof. The north elevation door retains the original 4'-8" weather canopy. The building is not blastproof and all Pad Support Crew are evacuated prior to launch.

**Facility 36006: Delta Operations Building (HAER No. FL-8-5-U)**

The Delta Operations Building, constructed in 1970, is located west of the blockhouse. The building houses additional administrative, engineering, and communication space to support launch activities. The one-story building contains 11,001 square feet and is constructed with a poured concrete foundation, concrete structure with concrete masonry unit infill, and a flat built-up roof. The building is equipped with aluminum and glass storefront doors but no windows.

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<sup>51</sup> As-Built Drawings, Security Upgrades, SLC 17, Cape Canaveral Air Station, Brown & Root Services Corporation, GSAC No. F04601-90-C-0080, January 1995.

Interior finishes consist of vinyl tile floors, drywall wall, a dropped ceiling with fluorescent light fixtures. (See photo FL-8-5-U-1 through FL-8-5-U-8)

**Facility 36009: Delta Horizontal Processing Facility (HAER No. FL-8-5-V)**

The Delta first and second stages are received, unpacked and inspected at Hangar M. The first and second stages are then moved to the Horizontal Processing Facility (HPF) and Area 55 for final pre-erection preparations and destruct charge installation. The stages are then moved to the launch pad for erection.<sup>52</sup>

The HPF was constructed in 1982 and contains 6,892 square feet. The HPF is dominated by the high-bay processing room. The room is constructed with a poured concrete foundation and floor, steel frame with aluminum wall sheathing, and low pitched standing seam metal roof. Both the east and west elevations contain highbay roll-up overhead doors to allow the stages to be moved in and out of the facility. Both elevations also contain two aluminum flush panel doors also. Nine aluminum frame windows extend the length of the north elevation to provide both additional light and ventilation. (See photo FL-8-5-V-1 through FL-8-5-V-8)

The south elevation contains two smaller one-story sections. Both sections are constructed with a poured concrete foundation, steel structure and aluminum sheathing, with a standing seam metal shed roof. The eastern-most section is equipped with double metal doors with louvers. A air conditioning unit is located adjacent to the doors. A large diameter aluminum vent pipe protrudes through the bottom of the south wall of this section and is braced along the exterior wall with brackets. The top of the pipe is arched and terminates approximately 4' above the roof line

The western section extends the remaining length of the high-bay room. This section contains four roll-up overhead doors, two aluminum flush panel doors. The west elevation is equipped with double metal doors also. A large diameter ventilation pipe protrudes from the roof of this section and terminates above the roof line of the high-bay room.

**Miscellaneous Complex Support Facilities**

**Facility 28414: Paint, Oil and Lubrication Building (HAER No. FL-8-5-W)**

The Paint, Oil, and Lubrication (POL) building is on the northwest side of the complex outside the perimeter fence. The one-story storage building was constructed in 1967 and contains 800 square feet. The building is constructed with a poured concrete foundation, concrete block walls and a shed roof. Four ventilators project above the low-pitched tar and gravel roof. Two double metal doors with louvers are located on the building's south side. The remaining three sides are equipped with metal louvers for ventilation. The concrete pad extends to the north and west side of the building. A corrugated metal and chainlink storage shed is attached to the building's north side. A steel beam and column frame wraps the north and west sides of the building. (See photo FL-8-5-W-1 through FL-8-5-W-5)

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<sup>52</sup> International Reference Guide To Space Launch Systems, p 213.

**Facility 28420: Machine Shop (HAER No. FL-8-5-X)**

The Machine Shop is west of the blockhouse and located outside the complex perimeter fence. The building was constructed in 1991 and contains 1517 square feet. The rectangular building is constructed with channeled concrete block over a poured reinforce concrete foundation. The medium pitched standing seam metal gable-on-hip roof is equipped with louvers in the gables for ventilation. Four doors provide access into the building. A flush panel metal door is located in both the north and south walls as well as two full-height roll-up metal doors located in the southeast and northwest corners of the building. Interior finishes consist of an exposed concrete floor with drywall ceiling and ceiling-mounted fluorescent lights. A small office is located in the southwest corner of the building. (See photo FL-8-5-X-1 through FL-8-5-X-4)

**Facility 28421: Paint Storage Shed (HAER No. FL-8-5-Y)**

The Paint Storage Shed is a 244 square foot structure constructed in 1993. The structure is constructed with a poured reinforced concrete floor, exposed steel columns, and corrugated metal roof deck supported by steel beams. (See photo FL-8-5-Y-1 and FL-8-5-Y-2)

**Facility 36002: Battery Laboratory (HAER No. FL-8-5-Z)**

The one and one-half story building, constructed in 1958, is rectangular in plan containing 386 square feet. The building is constructed with a concrete block foundation, walls, and a flat roof. All three original window openings have been filled with either concrete block or plywood. The concrete sill and lintel remain in place. Two windows contain wall-mounted air conditioning units while the third is equipped with metal louvers. A single metal door with wire glass provides access into the building. A concrete block flat-roof vestibule was added to the building's east side. The building is currently being used as a magnetic tape storage facility. (See photo FL-8-5-Z-1 through FL-8-5-Z-4)

**Facility 36003: Electrical Distribution Building (HAER No. FL-8-5-AA)**

The electrical distribution building is located adjacent to the south side of the blockhouse. This one-story building was constructed in 1958 and contains 744 square feet. The building is constructed with a concrete foundation and frame with concrete masonry unit infill. A small lean-to structure was added to the east side of the building. The flat built-up flat roof is equipped with an open frame steel structure. The building supplies electricity to the blockhouse and surrounding facilities. (See photo FL-8-5-AA-1 through FL-8-5-AA-4)

**Facility 36004: Locker and Storage Facility (HAER No. FL-8-5-BB)**

The Locker and Storage Facility was originally constructed in 1958 as the helium farm with an adjacent storage and equipment facility. The building is located southwest of the blockhouse. By 1975, the helium farm had been removed and a locker and breakroom facility was constructed

in its place. The building is constructed in two sections with a poured concrete foundation and concrete masonry unit walls. The northern section is one-story in height with a flat built-up roof. A steel door with metal awning is located on the north side. The southern section of the building was constructed as a high-bay area with a flat built-up roof. A steel and glass door is located on the east side of this section. The south elevation contains a full-width screen-in porch for crew breaks. Each section is equipped with a roof mounted ventilator. (See photo FL-8-5-BB-1 through FL-8-5-BB-4)

**Facility 36007: Sewage Treatment Plant (HAER No. FL-8-5-CC)**

The sewage treatment plant, constructed in 1970, is located northwest of complex. The plant processed the domestic waste water from the Support Building, Delta Operations building and the blockhouse. Sewage was pumped from the lift station, located adjacent to the Support Building, to the treatment plant.

The above-ground rectangular structure contained an aeration tank, sludge holding tank, two settling tanks, and a chlorine contact tank. The facility also contained two blowers and a hypochlorinator.

The treatment plant was constructed of 1/4" structural steel. The chlorine contact compartment had a capacity of 800 gallons. The hypochlorinator assembly was located below this compartment and consists of a solution tanks, suction and discharge valves, switches and outlets. The blower assembly provides pressurized air at 3 psi for various requirements.<sup>53</sup> The treatment plant was removed and all that remains is a concrete pad. (See photo FL-8-5-CC-1)

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<sup>53</sup>Technical Manual: NASA/DELTA d17.15.31.0, Operations and Maintenance, MST Propulsion Drive System, John F. Kennedy Space Center, September 1970, Section 1.

## BIBLIOGRAPHY

"Able-Star Works as Second Stage Booster," Aviation Week, 29 August 1960.

"A Summary of Major NASA Launches, October 1, 1958 - December 31, 1979." KSC Historical Report No. I, July 1980.

"Back To Mars Via a New Path." Aviation Week & Space Technology, 22 April 1996.

Barton, David and Levy, Richard S. "An Architectural and Engineering Survey and Evaluation of Facilities at Cape Canaveral Air Force Station, Brevard County, Florida," Bloomington, Indiana: Resource Analyst, Inc., 1984.

Basic Information Guide. Cape Canaveral, Facilities, Utilities, Instrumentation, Communications, Engineering and Environmental Planning Facilities Planning, Johns Controls World Services, 1994.

Berger, Carl and Howard, Warren S. "History of the 1st Strategic Aerospace Division and Vandenberg Air Force Base, 1957-1961," Vandenberg Air Force Base, California: Headquarters, 1st Strategic Aerospace Division, 1962.

Burrows, William E. Deep Black: Space Espionage and National Security. New York: Random House, 1986.

"Cape History: Establishment of the Eastern Test Range." Spaceport News, 14 October 1977.

Chronology of the Joint Long Range Proving Ground, Florida Missile Test Range and Atlantic Missile Range, 1938-1959. History Office, 6550th Air Base Group, Air Force Eastern Test Range, Air Force Systems Command.

Cleary, Mark. "List of Eastern Range Launches: Sites 17A and 17B." 45th Space Wing, Patrick Air Force Base, Florida.

Congress, House, Committee on Science and Technology, Subcommittee on Space Science and Applications, United States Civilian Space Programs, 1958-1978, report prepared by Science Policy Research Division (Marcia S. Smith and others), Congressional Research Service, Library of Congress, 97th Congress, 1st session., January 1981, Committee Print.

"Craft Is Launched To Explore Mars." New York Times Late New York Edition, 8 November 1996.

"Delta 3 Aims at Mid-Year Critical Design Review," Aviation Week & Space Technology, 11 March 1996.

"Delta 181 Shows Discrimination of Warheads Easier Than Predicted." Aviation Week & Space Technology, 7 March 1988.

"Encounter With EROS." Aviation Week & Space Technology, 12 February 1996.

"From Sand to Moondust: A Narrative of Cape Kennedy, Then and Now." United States Air Force and Pan American World Airways, Inc., 1974.

Grundman, Albert. McDonnell Douglas Engineer. Interview by authors, Tape recording, Cape Canaveral Air Station, Florida, 13 November 1996.

Handbook of ULO Facilities at the Eastern Test Range. Facilities Liaison Office, Unmanned Launch Operations, John F. Kennedy Space Center, NASA, Kennedy Space Center, Florida, May 1969.

Hartt, Julian. The Mighty Thor. New York: Duell, Sloan and Pearce, 1961.

Isakowitz, Steven J. International Reference Guide To Space Launch Systems. Washington D.C.: American Institute of Aeronautics and Astronautics, 1991.

James, R. E. James, ed. Handbook of Liquid Propellants. Martin Company Cocoa Division, 1961.

"Lark." The Range Quarterly, September 1965.

"Launch Unit Growing at Kennedy." Orlando Sentinel, 15 September 1968.

"Man In Space: Study of Alternatives." United States Department of the Interior, National Park Service, 1987.

"Master Plan of the Cape Canaveral Missile Test Annex." Pan American World Airways, Inc., 1971.

Nayler, J. L. A Dictionary of Astronautics. New York: Hart Publishing Company, Inc., 1964.

Neufeld, Jacob. "The Development of Ballistic Missiles in the United States Air Force, 1945-1960," Washington, D.C.: Office of Air Force History, United States Air Force, 1990.

"New Delta 3," Ad Astra, July/August 1995.

"New Mission Coming: Pad 17A Readied For Longer Delta." Spaceport News, 15 February 1968.

"Redstone." The Range Quarterly, September 1965.

Richelson, Jeffrey T. The United States' Secret Eyes in Space: The U.S. Keyhole Spy Satellite Program. New York: Harper & Row, 1990.

Scarboro, C. W. Twenty Years in Space: The Story of the United States' Spaceport. Cape Canaveral, FL: Scarboro Publications, 1969.

"SDI Delta Space Experiment To Aid Kill-Vehicle Design." Aviation Week & Space Technology, 15 September 1986.

"SDI Experiments Set for Launch in January." Aviation Week & Space Technology, 11 September 1989.

"SDI Test Takes Measure of Potential Targets," Science, 19 February 1988.

"SDIO Begins Measuring Booster Plumes With Delta Star Sensors." Aviation Week & Space Technology, 3 April 1989.

"SM-46383 Fixed Umbilical Mast." Missile & Space Systems Division, Douglas Aircraft Company, Inc., Santa Monica, CA, January 1965.

Space and Missile Systems Organization: A Chronology, 1954-1979. Los Angeles: SAMSO Headquarters, Space Division, Office of History, 1979.

"Technical Manual: NASA/DELTA d17.15.31.0." Operations and Maintenance, MST Propulsion Drive System, John F. Kennedy Space Center, September 1970.

"Thor-Able: Higher, Farther-A Moon-Probing Shot Next?," U.S. News & World Report, 18 July 1958.

"Thor Fact Sheet." News Release, Office of Information Services, Headquarters, Air Force Missile Test Center, Patrick Air Force Base, February 1959.

"Upgraded Delta 2 Launches NASA's XTE." Aviation Week & Space Technology, 8 January 1996.

United States Civilian Space Programs: Volume II, Application Satellites prepared for the Subcommittee on Space Science Applications of the Committee on Science and Technology, U.S. House of Representatives, 98th Congress, 1st session, May 1983.

"United States Launches Two More Satellites." Science, 22 April 1960.

"Vandenberg AFB Launch Summary ." Vandenberg Air Force Base, California: Headquarters, Strategic Missile Center, January 1991.

Winter, Frank H. Rockets Into Space. Cambridge, Mass.: Harvard University Press, 1990.

Young, Warren R., ed. To The Moon. New York, NY: Time-Life Records, 1969.